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A MEMOIR

ON

THE ECHINODERMATA

OF THE

ARCTIC SEA TO THE WEST OF GREENLAND.

BY

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Six Plates, and their Descriptions.

PREFACE.

The Echinodermata which form the subject of this memoir were collected during the voyage of H.M.SS. 'Alert' and 'Discovery,' under the command of Sir George S. Nares, R.N., K.C.B., F.R.S., to the Polar Sea, by the Naturalists attached to the Expedition, Capt. (now Major) H. W. Feilden and Mr. Hart. The greater number were obtained from 79° 20′ N. lat. to 82° 27′ N. lat. inclusive—that is, from Franklin-Pierce Bay to Floeberg Beach. Some forms were captured on the outward voyage, in 65° N. lat.; and others were dredged in the Expedition of H.M.S. 'Valorous,' between 66° 56′ and 70° 30′ N. lat., by Dr. J. Gwyn Jeffreys, F.R.S. One specimen was taken by Mr. A. C. Horner (who accompanied Sir Allen Young in the 'Pandora'), in Smith's Sound, 78° 19′ N. lat. The Arctic Circle has been regarded as our southern limit.

The collections were made under great difficulties, and especially those from the highest latitudes: dredging, when the tangles froze on coming out of the sea, could not be attempted frequently. Nevertheless the specimens collected were numerous. They were carefully cleaned; and some were preserved in spirit, and others were permitted to dry.

After being deposited at the Royal Society in 1877, the collection was forwarded to the British Museum. Dr. Günther, F.R.S., confided the specimens to the authors of this Memoir; and we wrote a brief description of them in the 'Annals & Magazine of Natural History,' 1877, vol. xx. pp. 449–470. Subsequently we contributed a short notice of these interesting objects to the admirable book written by Sir George

Nares, F.R.S., entitled 'A Narrative of a Voyage to the Polar Sea during 1875–1876,' published in 1878. In that short contribution we stated that the collection was so interesting and the specimens were so variable, that we should publish their description in a separate Monograph.

The Government Grant Committee of the Royal Society voted a sum of money in order to assist us in the production of this work.

We beg to thank Dr. Günther, F.R.S., in whose charge the specimens now are, Dr. J. Gwyn Jeffreys, F.R.S., the Rev. A. M. Norman, F.L.S., Dr. Carpenter, C.B., F.R.S., and Major Feilden especially for their kind assistance.

LIST OF THE SPECIES NOTICED AND DESCRIBED.

HOLOTHUROIDEA.

Cucumaria frondosa (*Gunner*), *Forbes.*
Cucumaria calcigera (*Stimpson*), *Selenka.*
Orcula Barthii, *Troschel.*
Psolus phantapus (*Strussenfeldt*), *Jæger.*
Psolus Fabricii (*Düben & Koren*), *Lütken.*
Chirodota lævis (*Fabricius*), *Grube.*
Myriotrochus Rinkii, *Steenstrup.*

ECHINOIDEA.

Strongylocentrotus dröbachiensis (*Müller*), *A. Agassiz.*

ASTEROIDEA.

Asteracanthion polare, *Müller & Troschel.*
Asteracanthion grœnlandicum (*Steenstrup*), *Lütken.*
Stichaster albulus (*Stimpson*), *Verrill.*
Cribrella oculata (*Linck*), *Forbes.*
Pedicellaster palæocrystallus, *Sladen.*
Crossaster papposus (*Linck*), *Müller & Troschel.*
Solaster endeca (*Gmelin*), *Forbes.*
Lophaster furcifer (*Düben & Koren*), *Verrill.*
Pteraster militaris (*O. F. Müller*), *Müller & Troschel.*
Ctenodiscus corniculatus (*Linck*), *Perrier.*

OPHIUROIDEA.

Ophiopleura arctica, *Duncan.*
Ophioglypha Sarsii, *Lütken.*
Ophioglypha robusta, *Ayres.*
Ophioglypha Stuwitzii, *Lütken.*
Ophiocten sericeum, *Forbes.*
Ophiopholis bellis, *Linck.*
Amphiura Holbœlli, *Lütken.*
Ophiacantha spinulosa, *Müller & Troschel.*

ASTROPHYTIDÆ.

Astrophyton Agassizii, *Stimpson.*

CRINOIDEA.

Antedon Eschrichtii (*Müller*), *Verrill.*
Antedon celtica (*Barrett*), *Norman.*
Antedon prolixa, *Sladen.*

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HOLOTHUROIDEA.

Judging from the results of such dredging as has hitherto been conducted in high latitudes, the Holothuroidea as a group do not appear to extend in the North-Atlantic area to a very great distance within the Arctic Circle. Exception must be made, however, in the case of *Myriotrochus Rinkii*, Stp., which was obtained by the Polar Expedition of 1875–76 in Discovery Bay, lat. 81° 41′ N., the most northern locality at which any Holothuroid has yet been found. The other members of the order have not been recorded in this area beyond the 70th parallel; but as they occur in higher latitudes elsewhere, it has been deemed expedient to include those which extend beyond the Arctic Circle (66° 30′ N.) in the present description.

The following is a list of the Holothuroids in question:—

1. *Cucumaria frondosa* (Gunner), Forbes.
2. *Cucumaria calcigera* (Stimp.), Selenka.
3. *Orcula Barthii*, Troschel.
4. *Psolus phantapus* (Strussenf.), Jäger.
5. *Psolus Fabricii* (D. & K.), Lütken.
6. *Chirodota lævis* (Fabr.), Grube.
7. *Myriotrochus Rinkii*, Steenstrup.

CUCUMARIA FRONDOSA (*Gunn.*), *Forbes.* Plate I, Figs. 1 & 2.

1767. *Holothuria frondosa*, Gunnerus, Act. Holm. 1767, p. 115, pl. iv. figs. 1, 2.
1776. *Holothuria frondosa*, O. F. Müller, Zool. Dan. Prodr. no. 2802.
1776. *Holothuria pentactes*, O. F. Müller, Zool. Dan. Prodr. no. 2806.
1780. *Holothuria pentactes*, Fabricius, Fauna Grœnlandica, p. 352. no. 343.
1780. *Holothuria frondosa*, Fabricius, Fauna Grœnlandica, p. 353. no. 344.
1780. ? *Holothuria minuta*, Fabricius, Fauna Grœnlandica, p. 354. no. 346.
1788. *Holothuria pentacta*, Gmelin (pars ?), Syst. Nat. Linn. ed. xiii. p. 3139.
1788. *Holothuria frondosa*, Gmelin, Syst. Nat. Linn. ed. xiii. p. 3138.
1788. *Holothuria pentactes*, O. F. Müller, Zool. Dan. vol. i. p. 36, pl. xxxi. fig. 8 (juv.).
1789. *Holothuria pentactes*, Abilgaard, Zool. Dan. vol. iii. p. 45, pl. cviii. figs. 1–4.
1806. *Holothuria pentactes*, Vahl et Rathke, Zool. Dan. vol. iv. pp. 3–7, pls. cxxiii.–cxxvii.
1816. *Holothuria frondosa*, Lamarck, Anim. s. Vert. ed. i. vol. iii. p. 73.
1833. *Pentacta frondosa*, Jäger, De Holothuriis, p. 12.
1834. *Cuvieria frondosa*, Blainville, Manuel d'Actinologie, p. 192.
1835. ? *Dactylota minuta*, Brandt, Prodr. descrip. anim. ab Mertensio obs., fasc. i. p. 45.
1835. ? *Cladodactyla pentactes*, Brandt, Prodr. descrip. anim. ab Mertensio obs., fasc. i. p. 45.
1839. *Holothuria grandis*, Forbes & Goodsir, Athenæum, no. 618, p. 647.
1839. *Cucumaria fucicola*, Forbes & Goodsir, Athenæum, no. 618, p. 647.
1841. *Cucumaria frondosa*, Forbes, Hist. British Starfishes, p. 209.
1841. *Cucumaria fucicola*, Forbes, Hist. British Starfishes, p. 227.
1841. ? *Cladodactyla pentactes*, Gould, Invert. of Massachusetts, p. 345.
1844. *Cucumaria frondosa*, Düben & Koren, K. Vet.-Akad. Handl. 1844, p. 293.
1852. *Bothryodactyla grandis*, Ayres, Proceed. Boston Soc. Nat. Hist. vol. iv. p. 52.
1852. *Bothryodactyla affinis*, Ayres, Proceed. Boston Soc. Nat. Hist. vol. iv. p. 145.
1852. ? *Cucumaria fucicola*, Forbes, Sutherland's Journ. of a Voyage &c,, vol. ii. Append. p. cexiv.
1853. *Pentacta frondosa*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 16.
1857. *Cucumaria frondosa*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 2.
1857. *Cucumaria frondosa*, M'Andrew & Barrett, Ann. & Mag. Nat. Hist. ser. 2, vol. xx. pp. 43, 45.
1861. *Cucumaria frondosa*, Sars, Oversigt af Norges Echinodermer, p. 100.
1863. *Pentacta frondosa*, Stimpson, Proc. Acad. N. Sci. Philad. 1863, p. 142.
1866. *Pentacta frondosa*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. pp. 352, 357.
1866. ? *Pentacta minuta*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 353.
1867. *Cucumaria frondosa*, Selenka, Zeitsch. f. wiss. Zool. Bd. xvii. p. 347.
1868. *Cucumaria frondosa*, Semper, Reisen im Archipel der Philippinen, Holothurien, pp. 52, 234.
1869. *Cucumaria frondosa*, Pourtales, Bull. Mus. Comp. Zool. Harvard, 1869, p. 359.

Body subcylindrical or subpentagonal in young stages, ovate in form when at rest and contracted, but capable of considerable elongation; uniformly rounded at both extremities.

The ambulacral sucker-feet are arranged in five longitudinal series, each being a double row in which the tube-feet alternate; in old specimens, however, a quadruple disposition in the middle of a series is not unfrequent, consequent on the action of growth-crowding, and a few additional irregularly-placed suckers also occur on the dorsal interradial areas, all the suckers being capable of entire retraction.

The skin is very thick, tough, and smooth, although specimens preserved in spirit are generally much wrinkled and puckered up, owing to the great contraction which the animal is capable of exerting prior to death through the medium of the powerful and largely developed muscular system which it possesses.

The tentacles are ten in number, frondose, equal-sized, and very robust in habit. The oral armature is, as a whole, large, although the calcareous mouth-ring in some examples is but very imperfectly calcified. The radial elements are somewhat of the form of an inverted Y, the muscular bands being attached to the extremity of the upward odd prolongation; the interradial pieces are smaller, and often in the form of a simple arch. The present writers have been unable to detect in any specimens they have examined the secondary ring mentioned by Selenka*; but in a single small example there seem to be traces of an incipient calcareous prolongation proceeding from the interradial piece, and giving it the "Y" shape similar to that of the radial elements. Perhaps such a development may be a stage towards the structure described by our learned contemporary.

In a young individual the Polian vesicle is single, and consists of a simple elongated sac, of moderate capacity, and about one third the length of the body. The respiratory organs, the intestine, and the generative organs are largely developed.

The muscular system is very powerful, the longitudinal bands being of such a breadth as to partially overlay the ampullæ of the sucker-feet; at the oral extremity they taper off rapidly, and their continuation forms the double band of the extensor muscles of the mouth-apparatus. The *m. retractores* are very strong and stout, the band being attached to the mouth-ring between the two fascicules of the extensor muscle. The series of transverse muscles are numerous and closely placed.

Very conflicting statements occur respecting the calcareous spicules in the cuticle, not only as to the form, but even as to the presence at all of such bodies in *C. frondosa*. Düben and Koren described the integument as covered with calcareous granules which are irregular, deformed, and never perforated. Selenka states that he has found no plates whatever in the general body-skin, but only very minute arragonite needles ·006 millim. in length; whilst both Semper and Lütken specify that large and perforated plates occur in this Holothuroid, but are only to be met with in the neighbourhood of the feet. Our observations tend to confirm the latter naturalists, although there would appear to be very considerable variation in the quantity of spicules present in different specimens. In some examples, for instance, the skin seems entirely devoid of any calcareous deposits whatever, whilst in others spicules are more or less numerous throughout the body; and this has been the case in moderately large examples. Generally, however, it must be said that spicules are most frequent in the neighbourhood of the ambulacral rows; but it would seem that no fixed rule of any kind can be definitely laid down as to their occurrence in this species, whilst the same remark would even hold good as to their form.

Size.—This species attains perhaps the largest size of any of the *Cucumariæ*, occasionally measuring a foot from end to end, large specimens being able to extend themselves to twice or three times this length.

Colour.—In colour *C. frondosa* is of a dark purple mingled with grey, shading off to ashy grey or white on the underside. Young examples are lighter and also of a more uniform shade, generally pinkish or flesh-coloured.

* "Beiträge zur Anatomie und Systematik der Holothurien," Zeitsch. f. wiss. Zool. Bd. xvii. p. 347.

Premature Form.—In early stages of growth the body is much more pentagonal in form and usually lighter in colour, which not unfrequently approaches a pinkish or flesh tint. The ambulacral sucker-feet are well spaced and arranged in single almost straight lines. In a small specimen 9 millims. in length the two dorsal ambulacral series are not so fully developed as the three ventral; they contain fewer suckers; and these are arranged in an almost straight line, except at the extremities, where the zigzag alternating character of the series is clearly manifest. The oral tentacles, although only partially extended in the specimen under notice, are already thick, frondose, and many times divided, whilst the body-skin is filled with regularly-spaced calcareous spicules roundish in form and punctured with holes, the solid interspaces being broader than the apertures. Comparing this individual with another somewhat larger, 20 millims. in length, it will be noted that the body is proportionately more elongate, the ambulacral feet more numerous, and now arranged distinctly in double rows of alternating suckers. The tentacular plume is slightly fuller, but still exactly the same in general character as in the earlier stage; in fact the changes above noted are the only conspicuous accompaniments of increased size perceptible to the naked eye. On microscopic examination, however, of the larger specimen it is found that no spicules are present in the skin; and this is a feature which at once constitutes the most striking difference between the two stages of growth. Such a circumstance is very remarkable; and although we are unable to say, with the limited amount of material at our disposal, whether this is a state of things which always obtains, at least two other individuals, of succeeding and still premature stages of growth, are equally wanting in spicules—a character which, as previously observed, is not unfrequent in the adult form of *C. frondosa.*

It is noteworthy that the features presented by the young specimen of 9 millims. accord exactly with those given by Lütken as characterizing *C. minuta*, Fabr. (excepting, we imagine, the tentacles); but on this point Lütken does not say much, as these organs were only partially extended in his specimen. If the view, therefore, which is here taken be correct, it would lead naturally to the deduction that *C. minuta* is nothing more than the young of *C. frondosa.* Before this can be definitely asserted, however, the examination of the growth-phases in a greater number of examples of the present species would be desirable; still we feel bound to say, after a very careful study of all the available material, that we are unable to separate the young form above described from the series of undoubted *C. frondosa*, the only feature in which it differs altogether from the older stages being the presence of the calcareous bodies in the integument.

From the description given, it would seem that the Holothuroid named by Forbes and Goodsir *C. fucicola* is a young form of the present species, a determination now generally concurred in by most naturalists.

Variations.—Amongst the list of synonyma will be found *Bothryodactyla grandis*, Ayres, which we have been led to include rather from a diffidence against dissenting from the opinion of so many eminent writers upon Holothuroids than from personal conviction. Indeed there would seem to be great doubt about the absolute identity of this form; for, although the main characters recited in the cursory description accord well enough

with those of *C. frondosa*, they are by themselves quite insufficient for comparative determination; whilst, on the other hand, it is definitely stated that the calcareous supports, though few, "are in the form of slender, perforated, crested spicula, similar to those found in *Thyone* and *Thyonidium*" (*l. c.* p. 53). Such crested spicules certainly do not occur in any specimens of *C. frondosa* from the North-European seas; whilst from the fact that they are specially noted by Mr. Ayres (and it is a feature much more readily passed over than not) we are inclined to regard *Bothryodactyla grandis*, if not an independent species, certainly with but little doubt as a well-marked variety. In further support of this opinion it may be noted that Sars examined specimens of the American *C. frondosa* both from Massachusetts and Fundy Bay, and specially asserts their identity with the European type.

Distribution.

a. *Greenland*: Godhavn, lat. 69° 14′ N. (*Stimpson, Lütken, 'Valorous' Exped.*).

b. *North of American Continent*: Assistance Bay, about lat. 74° N. (*Penny's Exped.*), the most northern locality on record; Labrador (*Verrill*); St. George's Bank, 30 fms. (*Verrill*); Grand Manan, low water, stony bottom (*Stimpson*); Massachusetts (*Gould*); Eastport, 20 fms., stony bottom (*Verrill*); Gulf of Georgia (*Selenka*); ? Florida Reef, 118 fms. (*Pourtales*); San Francisco (*Ayres*).

c. *North of European Continent*: Spitzbergen (*Lütken*); Scandinavian coasts, Iceland, Færoe Islands, Shetlands, British Islands.

Description of the Illustrations of this Species on Plate I.

Fig. 1. A medium-sized specimen: natural size.
2. A young specimen of the same species: natural size.

CUCUMARIA CALCIGERA (*Stimp.*), *Selenka.* Plate I, Figs. 3–8.

1851. *Pentacta calcigera*, Stimpson, Proceed. Boston Soc. Nat. Hist. vol. iv. p. 67.
1852. ? *Cucumaria Hyndmanni*, Forbes, Sutherland's Journal of a Voyage &c. vol. ii. Append. p. ccxiv.
1857. *Cucumaria Korenii*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 4.
1866. *Pentacta calcigera*, Verrill, Proc. Boston Soc. Nat. Hist. vol. x. p. 352.
1867. *Cucumaria Korenii*, Selenka, Zeitsch. f. wiss. Zool. Bd. xvii. p. 350.
1867. *Cucumaria calcigera*, Selenka, Zeitsch. f. wiss. Zool. Bd. xvii. p. 351.
1868. *Cucumaria calcigera*, Semper, Reisen im Archipel der Philippinen, Holothurien, p. 53.
1868. *Cucumaria Hyndmanni*, Semper (pars), *ibid.* p. 269.

Body elongate and cylindrical, the posterior third tapering gradually to a fine extremity; anterior end more rounded, and the median thickness of the body maintained till very much nearer the oral region. The body is generally more or less curved to one side, sometimes through more than half a circle, which gives to this species a crescent- or even horseshoe-shaped contour. The ambulacral feet are arranged in single pairs, and form five narrow, equally-developed bands. The suckers are placed very closely together; consequently the number extending from tip to tip is proportionally great, whilst sometimes, in the middle part of a band, the pairs become reduplicated by

reason of extreme crowding. Owing to the densely tessellated and compact nature of the integument, the sucker-feet are incapable of being perfectly retracted; and this circumstance, together with the size and general habit of the animal, affords a striking superficial feature, which readily characterizes the species amongst its Arctic congeners.

The cuticle, although thin, is very strong, being indurated with calcareous plates, of which two distinct layers are present; in each of these the plates are quite different both in size and form, and are so closely packed as to imbricate upon one another, whilst the whole Holothuroid is rough and scabrous to the touch, in consequence of a small spiculate elevation which rises from the centre of each of the plates that form the superficial layer.

The tentacles are ten in number, two being much smaller than the rest. They are of delicate habit, and redivided into many branches, which are fine and thin.

The mouth-ring is elongate, and resembles in a marked degree the form found in *Thyone*. It is composed of ten plates, each of which is made up of two elementary pieces, as may be well seen in the mouth-apparatus of a young specimen (Plate I, Fig. 4). The radial elements are produced upward into a fine wedge-shaped peak, and downward into two long, thin prolongations, which extend to the base of the apparatus, the cleft formed between them being wide and well arched above. The alternating interradial elements are somewhat wedge-shaped, equal in size to the upper portion of the radial processes, and extend upward to the same height as these. The angle of the plates, which abuts against the neighbouring radial member, is somewhat truncate, and the suture between the two primary pieces slightly hollowed out in the middle.

The Polian vesicle of a young individual is represented in Fig. 4, in which it is seen as a very distended sac, emanating midway upon a fine short tube.

According to Dr. Lütken (*l. c.*) the respiratory organs in the adult animal cleave immediately into four rays, one small and one larger on each side. They are but feebly branched; and although becoming generally thicker towards their extremities, it is only here and there that any thing like a vesicle can be detected.

Respecting the anatomy of the alimentary canal, it may be noted that the œsophagus is moderately developed, with its outer wall villate or densely covered with minute papillæ, and that the intestine is large and much convoluted.

The muscular system is somewhat small for a *Cucumaria*. The *m. longitudinales* are thin and very narrow, and the *m. transversales* similarly slight. The *m. retractores*, however, are strong and by far the most powerful bands of muscle in the animal; they are attached to the central part of the wedge-shaped upper portion of the radial member of the calcareous ring, and join the longitudinal band of muscles midway between the extremities. When the mouth-apparatus is retracted and these muscles are relieved from tension, they appear very broad in comparison with the other bands, and are, besides, much swollen out in their middle portion. The *m. extensores* are very fine indeed and double, and are affixed to the radial pieces of the ring a little above the attachment of the retractor muscles.

The reproductive organs consist of simple tubes. A figure is given of their condition in an early stage of growth (Plate I, Fig. 5).

The calcareous plates and spicules which indurate the integument are highly characteristic. As previously stated, they are so closely placed as to imbricate upon one another; and it is consequently very difficult to determine the form of individual pieces until separated by treatment in caustic potash. The plates which form the outermost layer vary in shape from roundish to oblong, and even irregularly stellate forms, their greatest diameter ranging from 0·28 to 0·35 millim. (Lütken). They are perforated with closely-placed holes, whose distance apart is less than their diameter, no plan being discernible in their arrangement. From the centre of each rises a subconical elevation, made up of fine calcareous rods, about one third as high as the diameter of the plate, and which terminates with two or three spikelets. It is to these spicular plates that the rough texture of the skin is due, and the granular appearance it presents when examined with a hand-magnifier of low power.

Underlying the plates just described is another layer of oblong and much narrower plates, also closely packed together and overlapping, and which are present in greater number over a given area in consequence of their smaller size. These pieces are generally punctured with two (or sometimes three) rows of holes, which become smaller in diameter towards the extremities of the plate.

The skin of the sucker-feet is comparatively as densely plated as that of the body, the spicules at the base being similar in character to those above described, but smaller in size; towards the extremity, however, they become much narrower, bear fewer holes, and are somewhat more curved, whilst mixed up with them may be found a number of quite rudimentary plates. When the great number of these scales and the method of their arrangement are borne in mind, the reason of the suckers being incapable of retraction becomes at once self-evident, as well as that of the small size of the internal ampullæ, which follows as a correlative result. The calcareous disk at the extremity of the sucker is well developed and very characteristic. It is a delicately fine circular network, having the immediate centre occupied with a number of small round holes, the rest of the piece being characterized by large subhexagonal apertures, which diminish in size as they approach the margin.

Respecting the affinities of *C. calcigera*, it may be said that although the form bears undoubted resemblance to *Cucumaria Hyndmanni*, Thomson, this is in external appearance only, as has been already pointed out by Düben and Koren*; whilst Lütken†, in his description of *C. Korenii*, specified in detail the differences which exist between the two species. As a fact, the calcareous plates are altogether different—in *C. Hyndmanni* being alike and constant in form, whilst in *C. Korenii* (=*C. calcigera*) there are not only two layers of quite distinct kinds, but the plates themselves vary very considerably. The plates also of the sucker-feet are broader, perforated with more holes, and are less regular and less uniform than in *C. Hyndmanni*; and, lastly, the fully-developed disk at the extremity of the sucker is characteristic of the present species.

* Kongl. Vetensk. Akad. Handl. år 1844, p. 299.

† Videnskabelige Meddelelser f. d. Naturh. Forening i Kjöbenhavn 1857 p. 6.

With this evidence in view, it is difficult to account for the grounds on which Semper*, after the examination of specimens, grouped the two forms as identical, merging *C. Korenii*, Lütken, into *C. Hyndmanni*. It consequently follows that his adopted association of *P. calcigera*, Stimpson, with *C. Hyndmanni* is equally erroneous.

Distribution.

a. *Greenland*: Godhavn, lat. 69° N. (*'Valorous' Exped.*); Fiskernæsset (*Lütken*); Arksut, 15–25 fms., mud bottom (*Barrett*).

b. *North of American Continent*: Assistance Bay, about lat. 74° N., 7–10 fms., muddy bottom (*Penny's Exped.*), the most northern locality on record; Labrador, 15 fms., sandy bottom (*Packard*, fide *Verrill*); Massachusetts (*Verrill*).

Description of the Illustrations of this Species on Plate I.

Fig. 3. *Cucumaria calcigera*: natural size.
4. Sketch of the mouth-ring and adjacent parts of a young individual: magnified.
5. Generative tubes at an early stage of growth: magnified.
6. Spicules of the superficial layer *in situ*: magnified.
7. Small spicule in profile: magnified.
8. Disk at the extremity of the sucker-foot: magnified.

Orcula Barthii, *Troschel.*

1846. *Orcula Barthii*, Troschel, Wiegm. Archiv f. Naturgesch. Jahrg. xii. p. 63.
1857. *Orcula Barthii*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 9.
1867. *Orcula Barthii*, Selenka, Zeitschr. f. wiss. Zool. Bd. xvii. p. 352.
1868. *Orcula Barthii*, Semper, Reison im Archipel der Philippinen, Holothurien, pp. 68, 274.

Dr. Lütken, in describing some Greenland examples of this Holothurian, states† that they present a regular sausage form, with a length (in one which seemed to have best preserved its natural proportions) of 3 inches and a thickness of over $\frac{3}{4}$ inch. The body-skin is brownish in colour, but almost concealed by the numerous bluish or whitish sucker-feet with which the whole body is closely crowded. Neither in the skin, which is thick and tough, nor in the feet is there any trace of solid calcareous formations. A thick layer of transverse muscles lies under the outer skin; and also five strong longitudinal bands, each of which gives off, at a distance from the anterior extremity equal to about one third the entire length of the animal, a short thick muscular bundle, which is attached to one of the radial elements of the œsophageal ring, whilst the main bands themselves are continued up to the anterior extremity of the body, and are then inclined backwards again, running as five thin narrow bands along the outer wall of the inverted œsophagus until they reach the points of the

* Reisen im Archipel der Philippinen, Holothurien, p. 237.

† The present writers having unfortunately had no opportunity of examining this Holothuroid, have accordingly availed themselves of giving the above translation of the observations made upon the form by Dr. Chr. Lütken, the eminent and accurate Danish zoologist, in the memoir above quoted.

same pieces of the mouth-ring to which the muscular bundles above mentioned are also attached. These thick transverse bundles are the *musculi retractores* of the œsophagus and tentacles, whilst the finer longitudinal bands outside the gullet function as *m. extensores*. As these are much weaker than the former, it is natural to find that the tentacles are, in all preserved examples, so thoroughly retracted that they can only be seen by cutting open the œsophagus. The tentacles, 15 in number (ten large and five very small, which alternate with them), are all finely branched as in *Cucumaria*. Immediately below their point of origin is situated the deep cartilaginous mouth-ring, which is composed of ten pieces merged together, five broad and five narrow, all forked below, the five narrow pieces terminating upward with one point, and the broader with two; and it is to these broader pieces that the above-mentioned muscular bands (*musculi retractores*) are attached. The Polian vesicle is long and thin, with moderately strong walls. The cloaca is clothed internally with a white sinewy skin; and from the outside pass fine muscular filaments by which it is attached to the body-wall of the animal. From the cloaca proceed the long thin-walled intestine and the respiratory apparatus, the latter presenting the usual character of thickly branched tubes, the branches being fine and dilated at the extremities into vesicles. On the side of the animal opposite to these organs, and, in the contracted condition, almost equidistant from either end, lies the reproductive apparatus, having the appearance of a bundle of fine, dilated, and here and there spool-shaped filaments.

Distribution.

a. *Greenland*: Holsteinborg, lat. 66° 56′ N. (*'Valorous' Exped.*: this species or new, fide *Norman*, loc. cit.), the most northern locality on record; Egedesminde, Julianshaab and Fiskernæsset (*Lütken*).

b. *North of American Continent*: Labrador (*Troschel*).

Psolus phantapus (*Strussenfeldt*), *Jäger*.

1765. *Holothuria phantapus*, Strussenfeldt, Act. Holm. 1765, p. 265, Taf. 10.
1766. *Holothuria phantapus*, Linné, Syst. Nat. ed. xii. p. 1089.
1776. *Holothuria phantapus*, O. F. Müller, Zool. Dan. Prodr. no. 2803.
1777. *Ascidia rustica*, Pennant, British Zoology, vol. iv. p. 48, pl. xxiii. fig. 35.
1789. *Holothuria phantapus* (Müller), Abildgaard, Zool. Dan. vol. iii. p. 54, tab. cxii., cxiii.
1816. *Holothuria phantapus*, Lamarck, Anim. s. Vert. ed. 1, vol. iii. p. 73.
1828. *Cuvieria phantapus*, Fleming, Hist. British Animals, p. 483.
1833. *Psolus phantapus*, Jäger, De Holothuriis, p. 21.
1834. *Cuvieria phantapus*, Blainville, Manuel d'Actinologie, p. 191, pl. 13. fig. 1.
1835. *Psolus phantapus*, Brandt, Prodr. Descrip. anim. ab Mertensio obs., fasc. i. p. 47.
1836. *Cuviera phantapus*, Johnston, Loudon's Mag. Nat. Hist. vol. ix. p. 472, fig. 68.
1841. *Psolus phantapus*, Forbes, Hist. British Starfishes, p. 203.
1844. *Cuvieria phantapus*, Düben & Koren, K. Vet.-Akad. Handl. 1844, p. 313.
1851. *Psolus lævigatus*, Ayres, Proceed. Boston Soc. Nat. Hist. vol. iv. pp. 25, 36.
1853. *Psolus phantapus*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 16.
1857. *Psolus phantapus*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 12.

1861. *Psolus phantapus*, Sars, Oversigt af Norges Echinodermer, p. 112.
1867. *Psolus phantapus*, Selenka, Zeitsch. f. wiss. Zool. Bd. xvii. p. 342.
1868. *Psolus phantapus*, Semper, Reisen im Archipel der Philippinen, Holothurien, pp. 62, 272.

The Rev. A. M. Norman, by whom the Echinodermata of the 'Valorous' Expedition were determined*, has kindly informed us that specimens of this Holothuroid were taken at Holsteinborg and Godhavn. The writers, not having had the opportunity of examining any Arctic examples of this well-known form, content themselves with simple reference to the principal literature and distribution of the species.

Distribution.

a. *Greenland*: Godhavn, lat. 69° 14′ (*'Valorous' Exped.*), the most northern locality on record; Holsteinborg Harbour (*'Valorous' Exped.*); Fiskernæsset (*Lütken*); Arksut (*Barrett*).

b. *North of American Continent*: Grand Manan, at low water and in 40 fms. (*Verrill*); Maine (*Stimpson*).

c. *North of European Continent*: Iceland, Færoe Islands, Finmark, Scandinavian coasts, British Isles.

Psolus Fabricii (*D. & K.*), *Lütken*. Plate I, Figs. 9–13.

1780. *Holothuria squamata*, Fabricius, Fauna Grœnlandica, p. 356. no. 348 (non O. F. M., nec D. & K.).
1841. *Holothuria squamata*, Gould, Invert. Anim. Massachusetts, p. 345.
1844. *Cuvieria Fabricii*, Düben & Koren, Kongl. Vet.-Akad. Handl. 1844, p. 316.
1851. *Cuvieria Fabricii*, Ayres, Proceed. Boston Soc. Nat. Hist. vol. iv. pp. 35–37.
1853. *Cuvieria Fabricii*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 16.
1857. *Psolus Fabricii*, Lütken, Vid. Meddel. N. Foroning i Kjöbenhavn, 1857, p. 13.
1866. *Lophothuria Fabricii*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 354.
1867. *Cuvieria Fabricii*, Selenka, Zeitschr. f. wiss. Zool. Bd. xvii. p. 343.
1868. *Psolus Fabricii*, Semper, Reisen im Archipel der Philippinen, Holothurien, pp. 62, 272.
1877. *Psolus Fabricii*, Marenzeller, Cœlent. Echin. u. Würmer d. öst.-ung. Nordpol.-Exped. p. 32 (Denksch. d. k. Akad. d. Wissensch. Wien, Bd. xxxv.).

Body somewhat limpet- or chiton-shaped, arched above and flat beneath; dorsal and ventral surfaces separated by a perfectly sharp angle, the contour of the periphery being oval. Both oral and anal apertures are situated upon the dorsal area, one at either extremity, and rather nearer to the margin than midway from the centre in the longitudinal axis of the body. The dorsal surface is covered with very large plate-like scales, which imbricate upon one another, their free margins being round in contour and directed centripetally; those in the neighbourhood of the apertures are somewhat smaller, and are grouped round the opening itself as the centre of their arrangement, whilst a number of the scales that immediately surround the orifice become developed into thick calcareous wart-like tubercles. Bordering the extreme outer edge of the dorsal area are about two rows of very much smaller scales, not more than one tenth

* In the "Preliminary Report of the Biological Results of a Cruise in H.M.S. 'Valorous' to Davis Strait in 1875," Proceed. Roy. Soc. vol. xxv. pp. 202–215.

the size of the others. The scales are densely covered with very large granules, but which in old specimens are not unfrequently abraded in places.

The integument of the ventral area, although thin, is tough and leathery, and presents no asperities to the touch. The ambulacral feet are entirely confined to the ventral area, and are limited to its extreme outer margin, round which the suckers form a broad border about four or five rows deep, very closely crowded, and having no perceptible order in their arrangement except in the outermost series, which are smaller than the rest, and form a line parallel with the margin. At the anterior and posterior ends of this oval marginal series may be found a few additional suckers extending along the median line: these are the rudiments of the aborted middle ambulacral series; and it is rare that more than four or five rows of four suckers each are present.

The mouth-ring resembles that of *P. squamatus*, D. & K., the elements having more or less the form of an inverted Y, and the five interradial pieces being smaller than the radials.

The Polian vesicle is large and single, the generative tubes extremely numerous and extensive, and the muscular system much more strongly developed than in *P. squamatus* (Lütken).

Respecting the spicules which occur in the cuticle of this Holothuroid, those of the ventral skin are indefinite in shape, and are more correctly described as calcareous reticulations having large circular apertures than as plates punctured with holes. Short prolongations frequently rise at right angles from the decussations or midway on the intercalary portions; and occasionally secondary branchings are formed from these. Here and there small cup-shaped spicules are to be met with, probably undeveloped stages of the larger spicules. The tubes of the sucker-feet are overlaid with spicules somewhat similar in shape and character to those of the ventral cuticle; and the extremity is provided with a large circular calcareous disk, likewise of reticulated structure, with the holes very large, close together, and nearly equal in size.

Colour and Size.—*Psolus Fabricii* is, when alive, of a dark red colour, which in spirit becomes changed to brown. Ayres speaks of his American specimens as being of a bright brick-red when alive (*loc. cit.* p. 36). One of the largest examples measured $3\frac{1}{2}$ inches in length and over 2 inches in breadth (*Lütken*).

Premature Form.—In a young state the dorsal surface is more depressed, and the orifices of the alimentary canal are somewhat nearer the margin than in the adult animal. The ambulacral feet are limited to a double row of suckers surrounding the margin of the ventral area; and no trace is visible of the median series. It is of interest to note that at this stage the young of the present species are almost undistinguishable from those of *Ps. phantapus* of a corresponding period of growth, although the latter is a form whose habit differs most strikingly from that of the present species when adult examples are compared. The same remark holds good for the young stages of *Ps. squamatus* as well, the superficial differences at an early phase being nothing more than slight variations in the character of the spicules that indurate the ventral cuticle.

Variations.—The preceding remarks respecting the resemblances that occur in the premature phases of three allied species (two of which at least are associated in the same waters) are of themselves sufficient to suggest the existence of ancestral affinities; and, indeed, so near is the relationship in one case that, although the impracticability of uniting the whole group is clearly apparent, the propriety of merging two of them, *Ps. Fabricii* and *Ps. squamatus*, is, in our opinion, far from questionable; for that *Ps. Fabricii* is in reality the outcome of locational variation from the *squamatus* type there would seem to be but little doubt. At the same time it is interesting to note the wide area over which the forms are found distributed and their divergence maintained—both *Ps. phantapus* (teste Sars) and *Ps. Fabricii* (teste Ayres) being found on the E. coast of North America, and having associated with them two allied forms, viz. *Ps. lævigatus*, Ayr., and *Ps. granulatus*, Ayr., both of which may, without much difficulty, be regarded as derivative forms when the whole group is passed in review.

Distribution.

a. *Greenland*: Holsteinborg, lat. 66° 56′ N. (*'Valorous' Exped.*); Jakobshavn, Julianshaab (*Lütken*).

b. *North of American Continent*: Newfoundland (*Lütken*); Grand Manan, 2–8 fms., adhering to rocks (*Verrill*); Massachusetts Bay.

c. ? *North of European Continent*: Lat. 74° 48′ N., long. 69° 26′ E. (*Weyprecht & Payer's Exped.*), the most northern locality on record.

Description of the Illustrations of this Species on Plate I.

Fig. 9. Dorsal aspect of the animal: natural size.
10. Ventral aspect of the same specimen: natural size.
11. Ventral aspect of a young specimen: natural size.
12. One of the small cup-like spicules of the ventral integument: magnified.
13. Spicules of the ventral integument: magnified.

CHIRODOTA LÆVIS (*Fabricius*), *Grube*. Plate I, Figs. 14–19.

1780. *Holothuria lævis*, Fabricius, Fauna Grœnlandica, p. 353. no. 345.
1806. ? *Holothuria pellucida* (Vahl), Rathke, Zool. Dan. vol. iv. p. 17, tab. cxxxv. fig. 1.
1829. *Chirodota discolor*, Eschscholtz, Zool. Atlas, Heft ii. p. 13, tab. x. fig. 2.
1833. *Pentacta lævis*, Jäger, De Holothuriis, p. 13.
1833. *Pentacta pellucida*, id. ibid.
1834. *Cucumaria lævis*, Blainville, Manuel d'Actinologie, p. 195.
1834. *Cucumaria pellucida*, id. ibid.
1835. *Dactylota lævis*, Brandt, Prodr. Descrip. anim. ab Mertensio obs., fasc. i. p. 45.
1835. *Dactylota pellucida*, id. ibid.
1835. *Chirodota discolor*, Brandt, loc. cit. p. 59.
1837. *Pentacta lævis*, Lamarck, Anim. s. Vert. ed. 3, vol. i. p. 553.
1837. *Pentacta pellucida*, id. ibid.
1851. ? *Thyonidium pellucidum*, Sars, Reise i Lofoten og Finmarken, p. 44.
1851. ? *Synapta coreacea*, Agassiz, Proc. Amer. Acad. vol. ii. p. 269.
1851. ? *Synapta rotifera*, Pourtales, Proc. Amer. Assoc. Adv. Sci. 1851, p. 15.

1851. *Chiridota lævis*, Grube, Middendorff's Sibirischo Reiso, Bd. ii. p. 41.
1851. ? *Chiridota discolor*, Grube, Middendorff's Sibirischo Reise, Bd. ii. p. 35.
1852. *Trochinus pallidus*, Ayres, Proc. Boston Soc. Nat. Hist. vol. iv. p. 243.
1853. *Chirodota lævis*, Stimpson, Mar. Invert. Grand Manan, p. 17.
1857. *Chiridota læve*, Lütken, Vid. Meddel. N. Foroning i Kjöbenhavn, 1857, p. 16.
1861. ? *Chirodota pellucida*, Sars, Oversigt af Norgos Echinodermor, p. 124, pls. 14–16.
1862. *Chirodota lævis*, Dujardin & Hupé, Hist. Nat. Zooph. Échinodermes, p. 616.
1866. *Chirodota læve*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 354.
1867. *Chirodota pellucida*, Selenka, Zoitsch. f. wiss. Zool. Bd. xvii. p. 366.
1867. ? *Chirodota tigillum*, Selenka, ibid.
1867. ? *Chirodota typica*, Selenka, ibid.
1868. *Chirodota lævis*, Semper, Holothurien, Reise im Archip. d. Phil. pp. 23, 267.
1868. *Chirodota pellucida*, Semper, Holothurien, Reise im Archip. d. Phil. pp. 23, 267, pl. v. fig. 2.

Body elongate and cylindrical, to which the absence of sucker-feet and of all hooklets or asperities imparts a strikingly vermiform appearance. Specimens preserved in spirit, however, are extremely contracted and generally contorted out of all natural shape. The skin is smooth, whitish, and semitransparent in spirit preparations; and the longitudinal muscles form five dense white bands extending from end to end and prominently marking out the interradial spaces. Within these areas are found a number of milk-white spots or sac-like papillæ, ranging up to a millimetre in diameter, and arranged in three of the interradia (which may be regarded as the dorsal area) in a fairly continuous line of about 20 to 30, whilst in the remaining two interradia, which form the ventral surface, there are not more than from 3 to 12, and these confined generally to the extremities, principally the anterior one. The white excrescences or sacculi are not all of uniform size; for a smaller one frequently alternates with a larger; and they contain a collection of the elegant wheel-shaped spicules which characterize this genus; and of these there may be as many as 90 or even more in the large spots. The wheels measure 0·1 millim. in diameter, and are uniformly six-rayed; the edge of the rim is bent over inwards and finely denticulated, a character which is only perceptible under certain methods of illumination; and this, as well as the manner in which the "spokes" are attached to it, seems to have been frequently misunderstood, and to have given rise in consequence to much diversity of opinion, since the differences were considered to be of specific importance.

The tentacles are twelve in number, and somewhat hand-shaped; and the digitations, of which there are 10–12, are capable of being closed in upon the "palm." The tentacles contain a few small spicules, which in the "fingers" are little more than simple elongate bodies; but nearer the base their extremities are enlarged and frequently either cleft or crenulate.

The mouth-ring is very compact, the elements being in such firm adherence as to convey the idea of a solid annulus; they are subquadrate in form, having the lower margin incurved, and on the upper a slight prominence with a small hollowing-out of the margin on either side of it; five of the pieces (alternately placed) are punctured for the nerve. On the unpunctured plates there is an elevation or crest-like prominence, somewhat in the form of an inverted Y.

The retractor muscles are thick and powerful, and attached along their length by a muscular membrane to their corresponding longitudinal band. The whole muscular system is very strongly developed, the longitudinal bands being remarkably thick and robust, whilst the transverse series are numerous and closely placed.

The Polian vesicles are long and thin, 10–15 in number, and of unequal length, the longer ones being twice (or even more) the length of the shorter.

The alimentary canal is nearly three times the length of the body, and is bent twice upon itself. Passing from the mouth it runs four fifths the length of the body; its course is then reversed, and the canal proceeds as far as the anterior third of the body, when it is again sharply bent backwards and passes to the anal extremity—the three lengths formed by the convolutions being held in their places by mesenteries.

The mesenteries attached to the two lower portions are accompanied along the line of their attachment to the body-wall by a longitudinal series of small pyriform bodies of peculiar shape, attached to a common cord which passes nearly up to the oral extremity—the "infundibular" organs or "Wimpertrichter." Their form is represented in Fig. 17; and it will be noted that they accord very nearly with those given by Sars of *C. pellucida*, and in like manner with those of a Greenland specimen of *C. lævis*, which are figured for comparison.

The generative organs consist of two series of long and extensive dichotomosing tubes connected together by a slender branch.

Size.—The largest example of this species has been recorded by Sars, and measured 100 millims. in length; generally, however, they range from 20 to 40 millims.

Premature Form.—In young stages the spots or sacculi which occur in the interradial areas are smaller in number and proportionally larger in size than in the adult animal. The calcareous wheels contained in the sacculi have both the spokes and the rim considerably broader in the old than in the young form. Young individuals have also fewer "fingers" on the tentacles, those of a small specimen 5 millims. in length having only six digitations to each (Sars).

Variations.—*Chirodota lævis* may unquestionably be regarded as a circumpolar species; and the modifications which it presents are comparatively slight. We are unable to consider the forms from Finmark and Lofoten, so carefully described by Sars under the name of *C. pellucida* (Vahl), as other than the representatives of *C. lævis*, the Greenland type of Fabricius and Lütken, the modifications which led Sars to place them as distinct species being frequently found much less pronounced, in both forms mutually, than in the specimens he examined. Amongst the specimens of this species procured by the 'Valorous' dredgings there are examples in which the form of the wheels and of the tubular infundibular organs accord perhaps more nearly with Sars's figures of *C. pellucida* than with those which he gives for comparison of the same structures from the specimen of *C. lævis* which he had dissected. Upon both of these points he placed great importance.

C. discolor, of Grube, from Behring's Straits, although presenting greater divergence than the above, seems indubitably to belong to the same type. The differences noted in the form of the wheels and the structure of the infundibular organs, as well as the

greater length of the alimentary canal and the longer and more attenuated generative sacs, are results which may not unnaturally be expected to arise when the distribution of the forms compared is kept in mind.

Distribution.

a. *Greenland*: Godhavn, lat. 69° 14′ N. (*'Valorous' Exped. & Hayes's Exped.*), the most northern locality on record.

b. *North of American Continent*: Labrador, 10 fms., sandy bottom (*Packard*, fide *Verrill*); Grand Manan (*Stimpson*); Eastport, under stones at low water (*Verrill*).

? Sitcha (under the name of *C. discolor*, Eschscholtz).

c. *North of European Continent*: Finmark and Lofoten, 1–2 fms., sand (*Sars*).

d. *North of Asiatic Continent*: Ochotsk Sea? (under the name of *C. discolor*, Grube, Middendorff's Exped.).

Description of the Illustrations of this Species on Plate I.

Fig. 14. The animal, much contracted: natural size.
15. Generative tubes: magnified.
16. Portion of the mouth-ring: magnified.
17. The pyriform infundibular organs or "Wimpertrichter:" magnified.
18. One of the wheel-like spicules: magnified.
19. One of the sacculi, to show the aggregation of the spicules: magnified.

Myriotrochus Rinkii, *Steenstrup*. Plate I, Figs. 20–24.

1851. *Myriotrochus Rinkii*, Steenstrup, Vid. Meddel. N. Forening i Kjöbenhavn, 1851, p. 55, pl. iii. figs. 7–10.
1852. *Chiridota brevis*, Huxley, Sutherland's 'Journal of a Voyage,' Append. vol. ii. p. ccxi.
1857. *Myriotrochus Rinkii*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 22.
1863. *Myriotrochus Rinkii*, Stimpson, Proc. Acad. Nat. Sci. Philad. 1863, p. 142.
1867. *Myriotrochus Rinkii*, Selenka, Zeitsch. f. wiss. Zool. Bd. xvii. p. 367.
1868. *Myriotrochus Rinkii*, Semper, Reisen im Archipel der Philippinen, Holothurien, p. 24.
1877. *Myriotrochus Rinkii* (? pars), Théel, Nova Acta Reg. Soc. Sci. Upsal. ser. 3, 1877, no. xvii. p. 3.

Body cylindrical, and tapering only slightly towards the posterior extremity, in some specimens the middle portion being somewhat swollen out, which causes the Holothuroid to present a slightly arched profile. Anterior extremity very broad and incapable of being retracted within the body, the habit of the animal being comparatively short and thick, the length not more than four or five times the thickness. The skin is smooth and whitish grey, and in some examples semitransparent, in which case the five longitudinal muscular bands as well as some of the internal organs are visible through the membrane. The surface of the body is overstrewn with large calcareous wheel-shaped spicules of characteristic form, attached to the integument by means of a short peduncle or prolongation of the skin, which is affixed to the central portion or "boss." This, however, is not easy to be seen in all the spicules, as some are closely appressed to the body, in consequence no doubt of muscular contraction. The spicules, as a rule, are more numerous upon the dorsal than upon the ventral surface; in some

specimens, however, they seem to be wanting altogether on the ventral interradia, and are confined to a few isolated spicules on the anterior and posterior extremities of the dorsal area.

The spicules are wheel-shaped and slightly concave outwardly, varying from ·2 to ·25 of a millim. in diameter. The spokes or radii, which are straight and slender, and are united into a central boss, average about nineteen in number; but they may vary by three or four more or less.

The circumference or portion which represents the outer rim is divided by sutures midway between each of the radial spokes; and prolongations given off from the margin, and bent sharply over at an acute angle, are directed inward towards the centre, and form a continuous series of equal, regular, elongate denticles. These denticles are about one third of a radius in length, generally somewhat three-sided in form; and their number frequently exceeds that of the spokes of the wheel.

The manner in which the spicules are developed is interesting, and is easily followed in some examples. The central boss is the first commencement, the margin of which becomes crenulated; and then denticles develop, which are gradually prolonged in the form of spokes until the full size of the wheel is attained; processes then form at the extremities at right angles to the spoke, and these eventually meet and coalesce with the corresponding processes from the neighbouring rays or spokes, whereby a continuous rim is formed equal in thickness to the rays; this rim next increases somewhat in breadth, and the inwardly directed denticles begin to develop from the margin.

The tentacles are twelve in number, and, judging from their structure, are somewhat hand-shaped, and would resemble when extended the form which is found in *Chirodota* (*cf.* Steenstrup, *loc. cit.*); when retracted, however, the upper portion is drawn within the basal part or stem of the tentacle itself, the membrane forming a kind of hood which arches over from the inward side, but leaves the extremities of the digitate prolongations exposed and visible on the outer side.

Within the broad circlet of the tentacles stretches a muscular membrane, in the centre of which the mouth-aperture is situated. The alimentary canal passes directly from this to the posterior portion of the animal, where it is bent upon itself, then two or three times sharply convoluted, and prolonged as far as the anterior third of the body, when its course is again reversed, and it finally passes direct to the anal aperture, this lower or intestinal portion being several times narrower than the rest of the canal (see fig. 22). The various convolutions are held in position by fine reticulated mesenteries.

The calcareous mouth-ring is very large and strong, and composed of ten ossicles; eight of these bear on their upperside a long, three-sided, wedge-shaped prolongation, whilst the remaining two, which are situated on either side of the median dorsal ossicle of the ring, have each two prolongations. Thus the prolongations correspond in number with the tentacles, the bases of the latter being situated between them, whilst a fine muscular band, which would seem to function as their retractor, stretches between the prolongations halfway between the base and tip. A foramen for the passage of the radial nerve is punctured through the prolongation, somewhat above its base.

The water-vascular ring is broad and conspicuous; and although only one Polian vesicle is developed, which is large and heart-shaped, a number of dilatations occur at intervals on the ring, which are suggestive of incipient or aborted vesicles (*cf.* fig. 24).

The generative organs consist of two groups of dichotomosing tubes which unite in a single duct, that makes its exit outside the tentacular ring. The sexes are distinct and readily distinguishable: in the female the tubes are shorter but very much broader, and the large-sized ova can generally be seen within; in the male, on the other hand, the tubes are longer and thinner as well as more numerous. In neither sex do these tubes, as a rule, extend beyond the anterior third of the body.

Premature Form.—We are unable to speak from personal observation of the growth-phases of *Myriotrochus*, as all the specimens at our disposal have been more or less perfectly developed. Dr. Hj. Théel* mentions an individual 10 millims. in length, presumably referable to this species, as the smallest he had examined. He states that "the skin contained a great quantity of the wheels in different stages of development, some even perfectly formed, although amongst the whole it was scarcely possible to find two that were identical. Many of the spicules had not more than six or ten radii, but bore twice that number, or even more, of the denticles. This example, which was a female, contained, notwithstanding its small size, fully developed eggs" (*loc. cit.*).

Variations.—On the whole, *Myriotrochus Rinkii* is a species that seems to undergo only very slight variation in form; the main difference which we have remarked occurs in the number of spicules that are present on the cuticle. For instance, in some examples the whole of the three dorsal interradia are closely filled with spicules, and a fair sprinkling is distributed over the ventral area as well; whilst, on the other hand, specimens are not rare in which these are confined to the median dorsal interradial area, with, perhaps, just a few on the edge of the adjoining areas, the ventral portion being quite bare, except three or four isolated wheels at the anterior extremity; and there are yet others even more sparingly provided, which have only a few isolated spicules at the extremities of the dorsal surface. Respecting the above-named variable character, we are bound to confess that we are at present unable to assign even a locational value to these modifications, since both extremes occur together in the material received from the most northern collecting-station recorded.

With these facts before us, it would seem that the characters upon which Sars founded his genus *Oligotrochus* are all to be found in *Myriotrochus*; and consequently no grounds exist on which that genus can be longer maintained. Indeed we have for some time been of opinion that even the species *O. vitreus*, Sars, could only be regarded as a variety comprehended within the form of *Myriotrochus Rinkii*; but a recent paper of Dr. Théel's, and a careful comparison of Sars's description and figures with the material we have had before us, lead to the conclusion that *Oligotrochus vitreus* may probably rank as a species of *Myriotrochus* allied to *M. Rinkii*; and we are also further inclined to think, from the description given, that Dr. Théel's specimens from Novaya Zemlya and the sea of Kara would accord more nearly with *Myriotrochus vitreus* than

* Nova Acta Reg. Soc. Sc. Upsal. ser. iii. 1877, no. xvii. p. 6.

with the Greenland form of Steenstrup's species. In one characteristic especially do they correspond with, and by the same differ from, the ordinary arctic forms of *M. Rinkii*. In this latter the spicules are attached to the skin by a kind of stalk or prolongation of the cuticular membrane, whilst in *O. vitreus* and Dr. Théel's specimens of *Myriotrochus* it is particularly mentioned that these are embedded in the skin itself. So marked is the feature, that amongst all his material Dr. Théel has never seen an indication of the "stalk;" and he is hence led to question the accuracy of Steenstrup's description in this respect, and to take, at the same time (quite erroneously, it would seem to us) certain words used by Prof. Huxley when describing *Chirodota brevis* as supporting the same conclusion (Théel, *l. c.* p. 4; Huxley, *l. c.* p. ccxii). Now it is very remarkable that, on the other hand, every specimen which we have examined, whether from Greenland or the extreme north, has the spicules attached by membranous stalks, and that this is a character which is at once apparent on examining them with no greater magnifying-power than a simple hand-glass. It is, in all probability, true that the spicules could be drawn more or less tightly down to the surface, as Steenstrup has already suggested, from the nature of their attachment (Steenstrup, *l. c.* p. 58); and in some rare cases, where the spicules have been abraded, there seem to be little cavities left in their place in the membrane; but we are disposed to believe that this results rather from the change which has taken place in the tissue around the closely appressed spicule whilst in spirit, than from a natural depression existing during life.

Distribution.

a. *Northward of Smith Sound*: Discovery Bay, lat. 81° 41′ N. (*Nares's Exped.*), the most northern locality on record; Port Foulke, lat. 78½° N. (*Stimpson*); lat. 69° 31′, 100 fms. (*'Valorous' Exped.*).

In Greenland: Godhavn; Omenak; Arksut, 10 fms., mud (*Lütken*); Germania Harbour in E. Greenland, 2 fms. (*Moebius*).

b. *North of American Continent*: Assistance Bay (*Penny's Exped.*); Labrador (*Packard*, fide *Verrill*).

c. *North of European Continent*: Spitzbergen (*Lütken*); Novaya Zemlya, 2–70 fms., clay; Vaigatch; Kara Sea, 11–60 fms., sandy clay; Sea of Murman (*Théel*).

Description of the Illustrations of this Species on Plate I.

Fig. 20. The animal: natural size.

21. One of the spicules: magnified.

22. Sketch of the internal organs, showing the relative proportions of the alimentary canal, the Polian vesicle, and the generative tubes.

23. Portion of the mouth-ring: magnified.

24. Underside of mouth-ring, with parts attached, seen from below, showing the dilatations of the oral water-vessel.

ECHINOIDEA.

One solitary species of Echinus is the sole representative of this large class in the Smith-Sound area; no other Echinoid passes in this direction from the North Atlantic up Davis Straits beyond the Arctic Circle. The form in question, *Strongylocentrotus dröbachiensis*, would, indeed, seem to hold undisputed sway in the boreal regions, being essentially and unequivocally circumpolar in its distribution, as will be seen from the list of localities appended below. Considerable variation is manifest, as might naturally be expected in so wide a range; but the stages are so gradual and the intermediate forms so constantly maintained, that no characters of specific value are recognizable amongst them; and we are, in this instance, presented with an interesting example of a species modified under the influence of various conditions of existence (habitat) alone, without the cooperation or hostile action of any closely allied competitive forms.

Strongylocentrotus dröbachiensis (*Müller*), *A. Agassiz*. Plate II. Figs. 1–3.

1776. *Echinus dröbachiensis*, O. F. Müller, Zool. Dan. Prodr. p. 235. no. 2846.
1780. *Echinus saxatilis*, Fabricius (non Müller), Fauna Grœnlandica, p. 372. no. 368.
1788. *Echinus dröbachiensis*, Gmelin, Syst. Nat. Linn. ed. xiii. p. 3169.
1816. *Echinus neglectus*, Lamarek, Anim. s. Vert. ed. i. vol. iii. p. 49.
1826. *Echinus granularis*, Say (non Lamarek), Proc. Aead. Nat. Sci. Philad. 1826, p. 225.
1828. *Echinus subangularis*, Fleming (non Leske), Hist. British Animals, p. 479.
1835. *Strongylocentrotus chlorocentrotus*, Brandt, Prod. Deseript. anim. ab Mertensio obs., fasc. i. p. 264.
1836. *Echinus neglectus*, Agassiz, Mém. Soe. Se. Nat. Neufehâtel, i. p. 190.
1837. *Echinus chlorocentrotus*, Des Moulins, Études sur les Échinides, p. 282.
1840. *Echinus granulatus*, Gould, Invert. of Massaehusetts, p. 344.
1841. *Echinus neglectus*, Forbes, Hist. British Starfishes, p. 172.
1844. *Echinus neglectus*, Düben & Koren, K. Vet.-Akad. Handl. 1844, p. 277.
1846. *Toxopneustes dröbachiensis*, Agassiz, Cat. rais., Ann. Sei. Nat. vi. p. 367.
1846. *Toxopneustes neglectus*, Agassiz, Cat. rais., Ann. Sei. Nat. vi. p. 367.
1846. *Toxopneustes granulatus*, Agassiz, Cat. rais., Ann. Sei. Nat. vi. p. 368.
1846. *Toxopneustes Dubenii*, Agassiz, Cat. rais., Ann. Sei. Nat. vi. p. 368.
1848. *Echinometra dröbachiensis*, Gray, British Radiata of the Brit. Museum, p. 4.
1851. *Echinus neglectus*, Brandt, Middendorff's Sibirisehe Reise, Bd. ii. p. 34.
1852. *Echinus neglectus*, Forbes, Suthorland's Journal of a Voyage &c. vol. ii. Append. p. ccxiv.
1853. *Echinus granulatus*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 15.
1857. *Toxopneustes dröbachiensis*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p 24.
1857. *Toxopneustes dröbachiensis*, Sars, Bidr. Middelhavets Littoral-Fauna, p. 115.
1857. *Echinus chloroticus*, Stimpson, Journ. Bost. Soe. Nat. Hist. vi. p. 86.
1858. *Toxopneustes neglectus*, Desor, Syn. des Échin. foss. p. 135.
1863. *Toxopneustes dröbachiensis*, A. Agassiz, Proceed. Boston Soc. Nat. Hist. 1863, p. 191.
1863. *Toxopneustes carnosus*, Barnard, in Agassiz, Proc. A. N. S. Philad. 1863, p. 357.
1863. *Toxopneustes chlorocentrotus*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1863, p. 144.
1863. *Toxopneustes granulatus*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1863, pp. 144, 148.
1866. *Euryechinus dröbachiensis*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. pp. 341, 352.

1866. *Euryechinus granulatus*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. pp. 340, 352.
1868. *Toxopneustes pictus*, Norman, Report Brit. Assoc. Adv. Sci. 1868, p. 314.
1871. *Toxopneustes pallidus*, G. O. Sars, Vidonsk. Selsk. Forhandl., Nye Echinodermer, p. 25.
1871. *Toxopneustes dröbachiensis*, Lovén, Ofvers. K. Vet.-Akad. Förhandl. 1871, no. 8.
1872. *Strongylocentrotus dröbachiensis*, A. Agassiz, Revision of the Echini, pp. 162, 277.
1877. *Strongylocentrotus dröbachiensis*, Marenzeller, Cœlent. Echin. u. Würmer d. öst.-ung. Nordpol-Exped. pp. 3, 29 (Denksch. d. k. Akad. d. Wissensch. Wien, Bd. xxxv.).

Test depressed, the height being proportional to the diameter as 1:2 approximately. Ambital outline almost circular, and only slightly subpentagonal; contour of the profile somewhat conoid, rounded at the apex. Test well rounded beneath, and incurved towards the interior at the margin of the actinostome. Actinostome large, and occupying three eighths or more of the diameter. Branchial notches very slight. Buccal membrane thin, and with comparatively few small, granulated, oblong scales and ten large buccal plates. Coronal plates comparatively high, each bearing one large primary tubercle, imperforate and uncrenulate. The series of these tubercles form two prominent vertical lines, which extend from the apex to the actinostome, both in the ambulacral and in the interambulacral areas. In the interambulacral areas the plates above the ambitus bear a number of miliary tubercles, which are disposed in an irregular manner around the primary tubercle, and form not unfrequently in small specimens a more or less clearly defined scrobicular ring; below the ambitus a secondary tubercle is present on each side of the primary, and, in fair-sized specimens of the Echinus, the external ones (which stand nearest to the poriferous zone) may be traced upon the abactinal surface of the test, extending in very rapidly diminishing series for some distance above the ambitus. In the ambulacral areas there is a small secondary tubercle on each plate on the inner side of the primary tubercle, the series diminishing in size as they approach the apex, in the neighbourhood of which the secondary tubercles become altogether undistinguishable from the few other miliaries which are present on the plate. Near the ambitus the miliaries are fairly numerous and irregular in size, the most conspicuous amongst them frequently forming, on the pore side of the plate, an arched row of three or four, which stands between the arc of pores and the tubercle, the adoral miliaries being largest. The pores are arranged in arcs of 5–6, those above the ambitus diverging only slightly from the vertical. The apical system is large, and also the anal ring, into which two ocular plates enter. The madreporiform and its companion anterior genital plate considerably exceed the other genital plates in size, which are often not much larger than the two entering ocular plates. The genital foramina are large. The spines are comparatively fine and delicate, and vary considerably in length, which ranges from 8 to 13 millims.

Colour.—The colour of the test is a varying shade of purplish brown, that of the spines greenish grey, the test being sometimes green in tint also.

Size.—The northern specimens are comparatively smaller than individuals from a more southern habitat. The largest example obtained during Sir George Nares's expedition was taken at Cape Napoleon, and measures 43 millims. in diameter, 21 millims. in height, and has 20 primary interambulacral tubercles.

The following are the measurements in millims. of
A, a specimen from Discovery Bay;
B, a specimen from the Dröbach Fjord.

	Diameter.	Height.	Anal system.	Actinostome.	Interamb. tubercles.
A . .	39	20	6	15·5	17
B . .	42	19	5	15·1	15

Variations.—Owing to the extensive range of this boreal Echinoid, the variations to which it is subject are so great that there are perhaps few other species which include in their list of synonyma so large a number of specific determinations. This arises from the fact that distant observers, depending too confidently upon the stability of "local forms," have founded upon these characters numerous so-called new species, all of which, however, have hitherto proved untenable when comparison has come to be made with a large series of specimens.

Thus a range of examples of the northern varieties, known as *S. granulatus* (Say), Gould, and *S. chlorocentrotus*, Brandt, fail to present any characters of sufficient importance to warrant their separation from the *dröbachiensis* group, although, when isolated and extreme examples are compared, the differences at first sight appear very marked.

When compared with what may be called a typical specimen, the test of the Arctic forms of *S. dröbachiensis* is relatively high, with the contour slightly more arched, and having a larger actinostome and apical disk. The greatest superficial difference, however, is presented by the spinulation. In some forms the spines of the abactinal surface are so small and delicate, and so widely spaced, that the Echinus has almost a naked appearance when placed beside others which are more uniformly clothed; and it will hardly be necessary to add that a corresponding modification exists in the size and uniformity of the tubercles upon which the spines are borne. The more densely-spined and more uniformly tuberculated urchin represents well the form known as *granulatus*; and a glance at two such extreme individuals as those just indicated will easily account for much of the confusion which has arisen in this species.

Both of these forms (the uniformly and the sparsely spined) occur together at several stations in Smith Sound, and extend even to Discovery Bay. At present we are unable to offer any definite explanation of the difference: possibly the variation may be due to stunted growth; or perhaps it may indicate a sexual character.

Distribution.

a. *Northward up Smith Sound*: Discovery Bay, lat. 81° 41′ N., 15–20 fms., muddy bottom (*Nares's Exped.*), the most northern locality on record; Richardson Bay, 70 fms.; Franklin-Pierce Bay, 13–15 fms., stony, bottom temperature 29°·5 Fahr.; Cape Napoleon; Hayes Point, 35 fms., bottom temperature 29°·5 Fahr. Greenland.

b. *North of American Continent*: Assistance Bay (*Penny's Exped.*). All the east

coast of N. America from Labrador to New Jersey, and probably even as far south as Cape Florida (*Würdemann*, fide *A. Agassiz*); west coast of N. America to Vancouver.

c. *North of European Continent*: Spitzbergen, Novaya Zemlya, Iceland, Færoe Islands, Scandinavian coasts, Britain.

d. *North of Asiatic Continent*: Behring's Straits, Kamtschatka, Ochotsk Sea (*Brandt*).

Description of the Illustrations of this Species on Plate II.

Fig. 1. An example of the thinly-spined form. Abactinal aspect: natural size.
2. The same specimen seen in profile: natural size.
3. Portion of the test near the ambitus, showing the ambulacral and interambulacral areas: magnified.

ASTEROIDEA.

All the Asteroids of the Smith-Sound fauna belong to well-known forms, with the single exception of *Pedicellaster palæocrystallus* from Discovery Bay and Cape Frazer. Several of the species are here recorded from much higher latitudes than they have previously been known to inhabit; and one of them, *Lophaster furcifer*, is found for the first time within the entreme boreal regions.

The following is a list of the Asteroids herein described from the Smith-Sound area, including all which have been found in the confluent portion of the N. Atlantic, north of the Arctic circle (66° 30′):—

1. *Asteracanthion polare*, Müller & Troschel.
2. *Asteracanthion grœnlandicum* (Steenstp.), Lütken.
3. *Stichaster albulus* (Stimps.), Verrill.
4. *Cribrella oculata* (Linck), Forbes.
5. *Pedicellaster palæocrystallus*, Sladen.
6. *Crossaster papposus* (Linck), M. & T.
7. *Solaster endeca* (Gmel.), Forbes.
8. *Lophaster furcifer* (D. & K.), Verrill.
9. *Pteraster militaris* (O. F. M.), M. & T.
10. *Ctenodiscus corniculatus* (Linck), Perrier.

Asteracanthion polare, *Müller & Troschel.* Plate II. Figs. 4–8.

1780. *Asterias rubens*, Fabricius (non Linné), Fauna Grœnlandica, p. 367, no. 362.
1780. *Asterias minuta*, Fabricius, Fauna Grœnlandica, p. 370. no. 365 (juv.).
1821. ?*Asterias violacea*, Sabine (non Müller), Append. Parry's Voyage, 1819–20 in 'Hecla' and 'Griper,' p. cexxiii.
1842. *Asteracanthion polaris*, Müller & Troschel, System der Asteriden, p. 16.
1851. ?*Asteracanthium ochotense*, Brandt, Middendorff's Reise in den äussersten Norden und Osten Sibiriens, Bd. ii. Th. 1, p. 28.
1857. *Asteracanthion polaris*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 28.
1862. *Asteracanthion rubens* (pars), Dujardin & Hupé, Hist. Nat. des Zooph. Échinodermes, p. 331.
1866. *Asterias polaris*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 356.
1869. *Asteracanthion polaris*?, Perrier, Recherches sur les Pédicellaires et les Ambulacres des Astéries et des Oursins, p. 33.
1875. *Asterias polaris*, Perrier, Révision des Stellérides, p. 58.

A Starfish of large robust habit, readily distinguishable from the other species of *Asteracanthion* which occur in the Arctic regions. Rays generally six in number, rounded, swollen at the sides, and tapering only at the extremity. Disk-radius to arm-radius as 1 : 4·4–4·75 approximately. Each adambulacral plate bears two ambulacral spines, which radiate apart from one another. In some specimens every pair throughout

the ray stands at the same angle to the plate, and thus two regular rows are formed on either side of the furrow. In others, however, each alternate pair of spinelets radiate at a rather smaller angle to the floor of the ray, the internal spine being directed further over the furrow, and the external one standing opposed to the interspace between the pairs of spinelets of the neighbouring plates; by this means an arrangement of four rows of spinelets on each side of the furrow is brought about, which, together with the swollen character of the sides, gives an appearance of considerable breadth to the ventral portion of the rays. The ambulacral spines are long, cylindrical, and rounded at the tip, not tapering or pointed in the slightest; and the innermost spine is somewhat thinner than the others. Pedicellariæ forficiformes are very numerous amongst the rows of ambulacral spinelets, and are densely crowded at the base of the rays in large specimens. The lateral spines, which are long, cylindrical, and somewhat crumpled or nipped together at the tip, form three longitudinal rows extending along the ray. In addition to these there is a short secondary row situate between the most ventral of the lateral series and the ambulacral spines; but, in consequence of the rapidity with which the spinelets diminish in size as they proceed outwards, this series extends only along the inner half of the ray.

In some large specimens there is often a short row of 6–8 supplementary spines at the base of the ray between the ventral and middle series of lateral spines; or a tendency to reduplication may be shown even in each of the rows at the extreme base of the ray. Occasionally the lateral spines are more or less tapering, those of the dorsal and median rows being also slightly curved upward.

The calcareous network of the abactinal surface is very robust, the membranous meshes or interspaces being in proportion comparatively small. The papulæ are, as a rule, single in young specimens; but in those of larger growth two or three occur together. The dorsal spinelets are large and cylindrical, not tapering, but nipped together at the tip, or even sometimes subclavate as in *A. violaceum*. They do not assume any lineal or regular arrangement whatever upon the abactinal surface. In some examples the dorsal spinelets are closely surrounded by a number of rather smaller subclavate spinelets, which give the appearance of compact groups of spines crowded together upon the abactinal surface of disk and rays alike.

Pedicellariæ forcipiformes, although very numerous upon the abactinal membrane, cannot be strictly said to form regular wreaths at the base of the dorsal spines; for whilst in some places they are much crowded, in others only three or four are present. In the lateral series, however, the spines of the upper or dorsal row are surrounded at their bases by a true wreath of pedicellariæ, whilst in the ventral or lower row the pedicellariæ are principally grouped on the dorsal or upper side of the base.

The pedicellariæ forficiformes, which are moderately numerous upon the abactinal surface, averaging perhaps one or two to a mesh, are densely crowded amongst the rows of ambulacral spines, especially on the innermost portion of the furrow. These pedicellariæ (p. forficiformes) are in the present species comparatively small, only a little longer than broad, and dumpy in form; the p. forcipiformes, on the other hand, are large, very gibbous, and truncate at the apex of the jaws.

The madreporiform body is situated in the interradius, about midway between the centre and the margin of the disk, but generally nearer the centre in fully developed specimens.

Size.—Large examples measure 230 millims. in diameter; and the species is known to attain even greater dimensions.

Colour.—Dr. Lütken, recording the observations made by Inspector Olrik upon the colour of this Starfish when alive, states that it is generally purple-red, and sometimes greyish olive-green.

Habitat.—According to the above-mentioned Danish naturalist, *A. polare* is to be found at low tides in May and June, but later in the year in deeper water (for instance, in August at 40 fathoms). This species was taken at Arksut by Mr. Barrett, from the shore down to 10 fathoms depth, on rocky bottom.

Premature Form.—A young specimen 28 millims. in diameter (the relative proportions of the disk and radii being 1 : 3·5 approximately) presents the following characters. The rays are broad and stout, tapering near the tip, and have their junction with the disk very frequently marked off by a sharp constriction in examples of this early age. The ossicles of the abactinal network are remarkably stout and robust, the interspaces being small and restricted in consequence; these are usually round in outline, with the membrane punctured by a single papula only, although two may occur occasionally. The dorsal spinelets are large and truncate, many quite subclavate, and are widely spaced over disk and rays alike without any regularity in their arrangement; their bases are closely surrounded by pedicellariæ forcipiformes, the large size of which is very striking in this young stage of the starfish, whilst similar pedicellariæ also accompany the secondary or intermediate spinelets, which occur with moderate frequency upon the imbricating ossicles. In the small specimen under notice, no pedicellariæ forficiformes have been detected upon the abactinal surface either of the disk or rays; there are, however, a few isolated ones on the margins of the furrows, but comparatively insignificant in size, and scarcely, if at all, larger than the p. forcipiformes of the abactinal surface.

The madreporiform body, which is large and deeply fissured, lies nearer the margin than in the adult forms, being situated about two thirds of the distance from the centre of the disk to the arm-angle.

Two longitudinal rows of lateral spines are present, one on the dorsal and the other on the ventral margin, the sides of the ray being vertical. The spinelets of both series are large, stout, cylindrical, and rounded at the tips; they are isolated and well spaced, the members of the upper series standing immediately over their ventral companions. In dried specimens the dorso-lateral row forms a conspicuous fringe along the margins of the ray, and the bases of the spinelets are surrounded by a wreath of pedicellariæ forcipiformes. These are also present at the bases of the ventro-lateral series, though not so numerous, and are there confined principally to the upper side of the spinelet. Between the ventro-lateral row and the ambulacral spines a short series of secondary spinelets extends along the inner half of the ray only; these are smaller, even at the base of the ray, than the other spinelets, and diminish rapidly in size as they proceed

outwards. The ambulacral spines are stout and cylindrical, two to each ambulacral plate; and every pair radiating at the same angle, a regular double row is formed on both sides of the furrow.

Variations.—The number of rays is very constant at six, although examples having only five are occasionally met with.

A considerable amount of variability occurs in the spinulation of the dorsal surface. In some specimens the spinelets are densely grouped, in others well spaced and with the encircling pedicellariæ more conspicuously displayed. The spines themselves are either cylindrical, with tips sharply pinched together, or fairly clavate and resembling in character the spinelets of *A. violaceum*, O. F. Müller. It would seem that these differences exist irrespective altogether of age or growth.

Similarly variable in character appears the arrangement of the ambulacral spinelets, as indicated by the deviation from the regular double row on either side the furrow to the fourfold series produced by the greater divergence of the alternating pairs. In fact, we are disposed to believe that the two modes of arrangement may be present on a single individual, and that it was probably such a specimen that M. Perrier referred with doubt to the species under notice, giving at the same time a most admirable and lucid description, which leaves no doubt as to the correctness of his determination*.

It may be inferred, from the description given in the 'Fauna Grœnlandica,' that *A. polare* and possibly also *A. grœnlandicum* were merged together by Fabricius under the designation of *Asterias rubens*; and it also seems highly probable that the Starfish there named *A. minuta* is nothing more than a young stage of the present species—an opinion which Dr. Lütken has already expressed†.

The description given by Brandt of *A. ochotense*, in Middendorff's 'Reise'‡, indicates a range of variation which leads to the assumption that more than one form may be there included. If such a view be correct, a part of the description there given would answer well for young forms of *A. polare*.

Müller and Troschel's type specimens of this species were also unquestionably young examples.

Distribution.

a. *Greenland*: W. coast of Davis Strait, about lat. 70° N. (*Sabine*); Upper Torske Bank, lat. 67° 50′ N., long. 55° 27′ W. (*'Valorous' Exped.*); lat. 66° 59′ N., long. 55° 27′ W., 57 fms. (*'Valorous' Exped.*); W. coast of Greenland, lat. 65° N. (*Nares's Exped.*); Arksut, lat. 61° 10′ N., long 48° 15′ W. (*Barrett*).

b. *North of American Continent*: Labrador (*Verrill*); St. George's Bank, 35–40 fms.

d. *North of Asiatic Continent*: Ochotsk Bay? (under the name of *A. ochotense*, Brandt).

* Perrier, Recherches sur les Pédicellaires et les Ambulacres des Astéries et des Oursins, 1869, p. 33.

† Vidensk. Meddel. Naturh. Forening i Kjöbenhavn for 1857, p. 29.

‡ Middendorff's 'Reise in den äussersten Norden und Osten Siberiens,' Bd. ii. Th. 1, p. 28.

Description of the Illustrations of this Species on Plate II.

Fig. 4. Abactinal aspect of the animal: reduced one half.
5. Actinal aspect of the same specimen: reduced one half.
6. Portion near the middle of a ray, actinal aspect: magnified.
7. Portion near the middle of a ray, abactinal aspect: magnified.
8. A similar portion from the more compactly spinulated variety of this species: magnified.

ASTERACANTHION GRŒNLANDICUM (*Steenstrup*), *Lütken*. Plate II, Figs. 9–12.

1852. ? *Uraster violacea*, Forbes (non Müller), Sutherland's 'Journal of a Voyage,' vol. ii. Append. p. ccxiv.
1853. *Asterias Mülleri*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 14.
1854. *Asteracanthion Mülleri*, Sars ?, var., Steenstrup, Vid. Meddel. N. Forening i Kjöbenhavn, 1854, p. 240.
1857. *Asteracanthion grœnlandicus*, Lütken, Vid. Meddol. N. Forening i Kjöbenhavn, 1857, p. 29.
1863. *Asterias grœnlandica*, Stimpson, Proc. Acad. N. Sci. Philad. 1863, p. 142.
1866. *Asterias grœnlandica*, Vorrill, Proc. Boston Soc. Nat. Hist. vol. x. p. 357.
1866. *Asterias grœnlandicus*, Gray, Synop. Spec. Starfish Brit. Mus. p. 2.

This species maintains a small habit, with five moderately thick arms, the proportion of disk-radius to arm-radius being 1 : 4·5 or 5. The ambulacral spines are rather long and cylindrical, and stand, in very irregular alternation, two and one to each adambulacral plate, the single spinelets having a position vertical to the floor of the furrow, whilst the pairs, on the other hand, radiate apart from one another in opposite directions. Except in young individuals, or near the extremity of the ray, the pairs are more numerous than the isolated spinelets, and are generally borne by two or three plates in succession, some rays even being regular for nearly half their length. The lateral spines, which occupy the sides of the ray, form, according to age, either two or three longitudinal series of isolated spinelets, not quite so long as the ambulacral series, and tapering slightly at their tips—the middle series, when present, being smaller than the others, and placed midway upon the lateral imbricating pieces. At the base of each of these lateral spines are a number of pedicellariæ forcipiformes, sometimes grouped and sometimes forming a more or less perfect encircling wreath, the latter generally upon the lower series.

The ossicles of the abactinal network that lie in the longitudinal direction of the ray are much shorter than those that occupy a transverse position; and being of delicate habit, the membranous interspaces are consequently large, as well as much broader than long. The dorsal spinelets are finer and shorter than those of the ventro-lateral series, and are placed in groups of two or three together at the intersections, whilst isolated spinelets occupy the intermediate intercalary ossicles, by which means, in consequence of the above-noted proportions of the elements of the calcareous framework, the character (although somewhat an irregular one) of a transverse arrangement of spinelets across the ray is produced. Upon the disk the spinelets are more closely placed; and this, in specimens preserved in spirit, gives quite a distinct appearance to that portion of

the Starfish; and, further, in some examples the disk-spinelets are also rather longer than those which are found upon the rays.

The papulæ are single. The pedicellariæ are not crowded, and generally either isolated or only two or three together. Pedicellariæ forcipiformes are as a rule not very numerous upon the dorsal surface of the rays, except towards the extremities, where they occur somewhat more abundantly. Those which accompany the lateral spines are situate near the middle of the shaft. Pedicellariæ forficiformes form a fringe along the sides of the ambulacral furrow. The madreporiform body is situated near the margin, and is frequently almost concealed by the spinelets that surround it.

Size.—This comparatively small species measures from 35 to 50 millims. in diameter, none of larger size having been recorded.

Colour.—According to Inspector Olrik's observations, made during life, small examples of *A. grœnlandicum* are described as of a greyish colour on a violet ground, and larger ones of a grey olive-green. All the specimens preserved in spirit which we have examined are entirely bleached, whilst the dried ones are of a dirty yellowish grey.

Habitat.—Mr. Barrett has taken this Starfish upon rocks near the shore; Insp. Olrik reports that he has dredged it at very various depths; and Capt. Feilden obtained the species from a depth of 80 fathoms, off Cape Frazer, during the British Arctic Expedition of 1875–76, under Capt. Sir George Nares.

Variations.—In this species considerable variation occurs in the general form and habit of the Starfish, as well as in the spinulation borne by the calcareous network of the test. There may, in fact, be set apart a long, thin-armed variety with the rays tapering but slightly, and another form in which the rays are broad, short, and sharply tapering at the extremity. The difference of character presented by the spinulation is perhaps even more conspicuous. In some specimens, for example, the spinelets of the abactinal surface of the rays are confined mainly to the groups that stand at the intersections of the network, the intermediate portions of the ossicles bearing only isolated spinelets, few and far between; whilst in others a very marked divergence is produced by the occurrence of well-developed and comparatively clustered groups of spinelets upon the intercalary pieces, as well as an increase in the number of those composing the main series. The effect of this tendency to develop an increased number of spines is perhaps most striking in its result on the lateral series, where, in consequence of the intercalating ossicle bearing a supplementary spinelet, an additional and intermediate longitudinal series is formed between the dorsal and ventral rows of lateral spines, extending in some cases almost to the extremity of the ray; and besides this, it not unfrequently happens that the development of extra spines is carried to such an extent that a regular reduplication of several of the lateral spinelets at the base of the rays takes place.

It must be remarked, however, that, beyond the simple record of the facts, the amount of material at our disposal is insufficient to warrant the expression of any decided opinion as to the significance which these modifications may bear; for, although at first sight it would seem probable that these were only the conditions of age and growth, a careful study of the specimens which we have examined, together with the consideration of the influence of habitat, lead us to favour the belief that the structural changes above

noted may mark the effect of conditions of environment, and thus represent the steps of an actual locational divergence in the species under notice. A much larger series is needed, however, from various localities, before a definite statement can be made upon this subject.

Distribution.

a. *Northward of Smith Sound*: Discovery Bay, lat. 81° 41′ N., 25 fms. (*Nares's Exped.*), the most northern locality on record; Port Foulke (*Stimpson*).

b. *North of American Continent*: Assistance Bay (under the name of *Uraster violaceus*, Forbes, *Penny's Exped.*); Labrador (*Packard*); Newfoundland (*Lütken*); Gulf of St. Lawrence, near Anticosti (*Verrill*); Grand Manan (under name of *A. Mülleri*, Stimpson).

c. *North of European Continent*: Off S.W. coast of Novaya Zemlya, lat. 71° 6′ N., long. 50° E., 62 fms. (*'Willem Barents' Exped.*).

Description of the Illustrations of this Species on Plate II.

Fig. 9. Abactinal aspect of the animal: natural size.
10. Actinal aspect of the same specimen: natural size.
11. Portion near the middle of a ray, actinal aspect; magnified.
12. Portion near the middle of a ray, abactinal aspect: magnified.

STICHASTER ALBULUS (*Stimps.*), *Verrill.* Plate II, Figs. 13–17.

1842. *Asteracanthion roseus* (pars), Müller and Troschel, System der Asteriden, p. 17.
1853. *Asteracanthion albulus*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 14.
1855. *Asteracanthion problema*, Steenstrup, Vid. Meddel. N. Forening i Kjöbenhavn, 1854, p. 240.
1857. *Asteracanthion problema*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 30.
1863. *Asterias albula*, Stimpson, Proc. Acad. N. Sci. Philad. 1863, p. 142.
1866. *Stichaster albulus*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 351.
1875. *Stichaster albulus*, Perrier, Stellérides du Muséum, p. 82; Arch. de Zool. exp. et gén. vol. iv. p. 346.

A small Starfish with narrow disk and rounded or somewhat arched rays, the number of which is almost invariably six, three rays on one side being as a rule very much shorter than those on the other. Proportion of the diameter of the disk to that of the arms 1 : 5 or rather more. The ambulacral furrows are wide, with suckers arranged in zigzag series, forming two or four rows, according to age and size. Each adambulacral plate bears two "ambulacral" spines which radiate slightly right and left, and form regular rows; occasionally in larger specimens an additional spine accompanying the ten or twenty innermost pairs of the ray. Closely succeeding to these, there follows on the side of the arm a slightly oblique series of three (or, in large specimens, four) similar spinelets, representing ventro-lateral spines, but not always a series opposite

to each adambulacral plate, owing to the plates which bear the spines being more widely spaced. The abactinal body-frame is formed of transverse bands of ossicles; and these are packed closely together in longitudinal series along the ray: the plates are very uniform in size; and as each generally stands opposed to a corresponding plate in the neighbouring transverse row, a fairly regular rectilinear arrangement is the result. The median ossicles, which are somewhat larger than the rest, imbricate upon one another and form a distinct line along the ray. The membranous interspaces are of moderate size and punctured with one or two papulæ. Each ossicle bears a small subquadrate group of from three to five short dorsal spines, amongst them being placed two or three of the pedicellariæ forcipiformes, but which are somewhat more numerous towards the sides of the ray. The spine-groups, in consequence of the regularity of the network, are disposed in longitudinal and transverse lines, those of the middle row being rather larger and more densely packed than the others, and thereby forming a more or less distinct median line down each ray. From the apices of the spines, which are broader than the bases, proceed three or four small denticles; and the spinelets being all of equal length and closely set, give a smooth velvet appearance to the Starfish. Pedicellariæ forficiformes are found along the margins of the ambulacral furrow at intervals of every two or three plates, but are comparatively small in size, short, and somewhat rounded or obtuse at the points. Two or three larger ones are frequently met with in the neighbourhood of the actinostome, often quite gigantic; and a few isolated individuals also occur on the dorsal surface, but seldom beyond the base of the rays; these, it need scarcely be said, are considerably larger than the p. forcipiformes which accompany the spine-groups above mentioned. The p. forcipiformes that occur on the lateral portions of the rays are, as a rule, situate on the aboral or outward side of the spines. The madreporiform body is situated near the margin, and is large, simple (having but few striæ), and surrounded by a circlet of the dorsal spines.

Size.—This species seldom measures more than from one inch to an inch and a half in diameter, and is generally less. A variety, noted below, is recorded from Eastport 4 inches in diameter.

Colour.—In a living state *Stichaster albulus* is described as of a faint red or cream-colour. When dried, or in spirit, it is usually light yellow, varying to more or less warm shades of light brown.

Habitat.—On stony ground and Laminaria in 5–20 fathoms, and seldom in greater depths (*Olrik*). It has been taken by Barrett in from 3–25 fathoms, also on stony ground (*Lütken*, *l. c.* p. 30). Verrill similarly records its occurrence on the coast of Maine and Grand Manan, in 10–20 fathoms, on rocky bottoms and among Nullipores, and frequent also at low water of spring-tides among rocks (*l. c.* p. 351). Stimpson states that at Grand Manan the species occurred most frequently among branching Nullipores in 4 or 5 fathoms on the east side of the island.

Variations.—Although the number of rays in this species is almost invariably six, about two per cent. of the specimens collected have only five, according to Stimpson's observations at Grand Manan; and examples with seven occur occasionally. The same authority also records that four out of five had three of the rays much larger than the others.

Verrill has described * a variety under the name of *nitida*, taken at Eastport, Maine, at low water, but which, in his opinion, presents no peculiarities which may not be considered due to increased age. The specimen is remarkable for its large size (4 inches in diameter) and regular form. The rays are equal, and the median row of plates quite distinct. The lateral spines are four or five in number, in a transverse row, those nearest the ambulacra being longest. The adambulacral plates bear two, three, or sometimes four long, tapering, and rather slender spines. The dorsal plates are crowned by eight to twelve small, somewhat radiating spines, thicker and more obtuse than those of the ordinary variety. The papulæ are not very numerous, rather large, and occur mostly in pairs. Suckers numerous and much crowded, in four rows.

Judging from the description alone of a single specimen, it would be difficult to say whether the modifications above noted possess any greater significance than mere conditions of growth. Augmentation in the number of ambulacral and lateral spines, as well as of those upon the ossicles of the disk, greater development of the median row, increase in the number of papulæ, and crowding and increase of the ambulacral suckers, are, it is true, changes that accompany structural growth; still, if we are only to give these characters such a value in the present case, it seems strange that the form in question is not of more frequent occurrence in localities where *Stichaster albulus* may be taken in the utmost abundance.

A single large example which may be referred to this variety was dredged at Proven during the outward journey of Capt. Nares's Arctic Expedition, the diameters of the rays and disk being respectively 30 millims. and 6 millims.

Comparing specimens from the coast of Maine with those from Franklin-Pierce Bay (lat. 79° 25′ N.), we have detected no remarkable difference; and Mr. Verrill records the same conclusions in regard to specimens from Greenland which he had studied.

Distribution.

a. *Northward of Smith Sound*: Franklin-Pierce Bay, lat. 79° 25′ N., 15 fms. (*Nares's Exped.*), the most northern locality on record.

In Davis Strait: Godhavn Harbour and Holsteinborg (*'Valorous' Exped.*); Proven, 13 fms. (*Nares's Exped.*).

b. *North of American Continent*: Grand Manan (*Stimpson*); Eastport, Maine (*Verrill*).

c. *North of European Continent*: Spitzbergen (*Lütken*); Iceland, Öfjord (*Lütken*).

Description of the Illustrations of this Species on Plate II.

Fig. 13. Abactinal aspect of the animal: natural size.

14. A larger and almost equal-rayed variety from Proven.

* Proceed. Boston Soc. Nat. Hist. vol. x. p. 351.

Fig. 15. Actinal aspect of the same specimen: natural size.
16. Portion near the middle of a ray, actinal aspect: magnified.
17. Portion near the middle of a ray, abactinal aspect: magnified.

CRIBRELLA OCULATA (*Linck*), *Forbes*. Plate II, Figs. 18–21.

1733. *Pentadactylosaster oculatus*, Linck, De Stellis marinis, p. 35, pl. xxxvi. No. 62.
1776. *Asterias sanguinolenta*, O. F. Müller, Zool. Dan. Prodr. p. 234, No. 2836.
1776. *Asterias pertusa*, O. F. Müller, Zool. Dan. Prodr. p. 235, No. 2839.
1777. *Asterias oculata*, Pennant, British Zoology, vol. iv. p. 61, pl. xxx. fig. 56.
1780. *Asterias spongiosa*, Fabricius, Fauna Grœnlandica, p. 368, No. 363.
1805. *Asterias seposita*, Retzius, Dissert. sist. spec. cog. Asteriarum, p. 21.
1823. *Asterias pertusa*, Fabricius, K. Danske Vid. Selsk. Skrifter, vol. ii. p. 41, pl. iv. fig. 2.
1828. *Asterias oculata*, Fleming, Hist. British Animals, p. 487.
1839. *Linckia oculata*, Forbes, Mem. Wern. Soc. vol. viii. p. 120.
1840. *Henricia oculata*, Gray, Ann. & Mag. Nat. Hist. vol. vi. p. 184.
1841. *Asterias spongiosa*, Gould, Invert. of Massachusetts, p. 345.
1841. *Cribella oculata*, Forbes, Hist. British Starfishes, p. 100.
1842. *Echinaster oculatus*, Müller & Troschel, System der Asteriden, pp. 24, 127.
1842. *Echinaster Eschrichtii*, Müller & Troschel, System der Asteriden, p. 25.
1844. *Echinaster sanguinolentus*, Sars, Wiegm. Arch. f. Naturgeschichte, vol. x. p. 16.
1844. *Echinaster Sarsii*, Müller & Troschel, Wiegm. Arch. f. Naturgeschichte, vol. x. p. 179.
1844. *Echinaster oculatus*, Düben & Koren, K. Vet. Akad. Handl. 1844, p. 241.
1848. *Asterias spongiosa*, Desor, Proceed. Boston Soc. Nat. Hist. vol. iii. p. 67.
1851. *Echinaster Eschrichtii*, Brandt, Middendorff's Sibirische Reise, vol. ii. p. 32.
1853. *Linckia oculata*, Stimpson, Invert. Grand Manan, p. 14.
1853. *Linckia pertusa*, Stimpson, ibid.
1857. *Cribrella sanguinolenta*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 31.
1862. *Cribella sanguinolenta*, Dujardin & Hupé, Hist. Nat. Zooph. Échinodermes, p. 349.
1862. *Cribella Eschrichtii*, id. ibid.
1865. *Cribrella sanguinolenta*, Norman, Ann. & Mag. Nat. Hist. ser. 3, vol. xv. p. 124.
1866. *Henricia oculata*, Gray, Synop. Spec. Starf. Brit. Mus. p. 5.
1866. *Cribrella sanguinolenta*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 345.
1866. *Echinaster oculatus*, von Martens, Troschel's Archiv f. Naturgesch. Jg. 32, i. p. 84.
1869. *Echinaster oculatus*, Perrier, Rech. sur les Pédicell. et les Ambul. p. 57.
1875. *Cribrella oculata*, Perrier, Stellérides du Muséum, p. 109; Arch. d. Zool. exp. et gén. iv. p. 373.

Rays normally five in number, although examples with six or seven are occasionally found. Proportion of disk- to arm-radius 1:4 or 5. The arms are round, excepting a slight flattening on the under surface, and long, slender, and more or less tapering towards the extremity. In some specimens there is a considerable swelling-out of the ray at the base, followed by a constriction at the junction with the disk—a feature which is generally most developed in female specimens in egg, and must probably be regarded in a great measure as simply a character dependent on sex.

The abactinal network is composed of very short stout ossicula, irregularly and very closely reticulated, the interspaces being small in area, in correspondence with the shortness of the calcareous elements. The ossicula bear more or less compact groups of fine spinelets, which vary in number, size, and habit, the spinelets themselves being

3–5-laminate and correspondingly denticulate at the apex. The membrane of the interspaces is punctured for papulæ, of which, in young stages of growth, seldom more than one is present in each ; but in specimens of larger size one to four or more may be found. The ventro-lateral plates form two or three series, and their spinelet-groups are arranged at right angles, or sometimes slightly diagonally, to the median line of the ray. The foot-papillæ are somewhat larger and stouter than the rest of the spinulation ; those which form the immediate margin of the ambulacral furrow consist of one or two still stouter spinelets, which at an early age are generally arranged in single file upon the adambulacral plate, and are followed by 2–4 pairs of spinelets merging gradually into the size of those of the ventro-lateral series. At a more advanced stage of growth the innermost foot-papillæ have not unfrequently become arranged as a pair of spinelets, very obliquely placed upon the plate, and followed by one or two of similar size and character, these in turn being succeeded by the series of intermediate spinelets forming the transition into the ventro-lateral spinulation. Occasionally the innermost spinelets form an oblique comb-like arrangement on the plate. Each adambulacral plate also bears another spinelet, very small in size, situated high up in the furrow, and generally invisible to superficial examination. The anal orifice is central and conspicuous. The madreporiform body is large and irregular in form, and situated midway between the margin and the centre ; in young stages it is covered with spinelets, but in older specimens these very frequently disappear, leaving visible the more or less irregular arrangement of curved and dichotomosing striæ that intersect the organ.

Size.—The largest Greenland specimen is cited by Lütken as 140 millims., whilst Sars mentions one 165 millims. in diameter from Esmark in Christiania Fjord. The usual size is from 50 to 75 millims.

Colour.—The Greenland specimens are described as brick-red when alive (*Lütken*). Those on our own coasts are generally dark red or deep purple above and straw-coloured beneath, whilst occasionally bright vermilion is met with (*Forbes*). A bright saffron-yellow variety occurs at Bergen (*D. & K.*) and Shetlands (*Norman*), which is a thick-armed deep-water form ; and it is also on record that the same form was taken off Fife by Henry Goodsir. In the Asiatic specimens brought home by Von Middendorff's Expedition, bluish or purple tints seem to have prevailed on the dorsal side, the underside varying from vermilion to flesh-colour (*Brandt, Midd. Reise*, p. 34).

Habitat.—From the shore to 175 fathoms depth—a specimen being taken at this last-named depth off Hare Island, Waigat Strait, during the ' Valorous ' Expedition.

Premature Form.—In young examples the length of the ray is much less in proportion to the disk than in the adult Starfish. The arms are also relatively wider at the base, and taper more rapidly to the extremity. The spinulation of the dorsal surface is very delicate, in fact almost microscopic, and the ossicles bear fewer spinelets, which are associated in more compact groups. The ventro-lateral series are more distinctly defined from the rest of the spinulation than at a greater age, two to four lateral rows, in addition to the foot-papillæ series, being clearly discernible. Seldom more than a single papula is present in the interspaces of the dorsal network, and the madreporiform body is more prominently covered with long spines.

Variations.—Much variation occurs in this species, as might naturally be expected in an organism enjoying such a wide geographical range; indeed some of the divergencies are so well marked that they have from time to time been taken by several writers as types of distinct species. Thus *Echinaster Sarsii*, M. & T., is in reality nothing more than the young phase of our Greenland form, whilst its adult stage has served as the type of *Echinaster Eschrichtii*, M. & T. (=*Asterias pertusa*, Müller). Similarly *Linckia* (*Cribella*) *oculata*, Forbes (the *Asterias spongiosa* of Gould), is the shorter-armed and more densely spinulated variety of the species, and which inhabits, as a rule, the southern portion of the area of distribution. All these forms, however, when studied in series, are found to fall, by imperceptible gradations, into simple modifications of the Starfish named by O. F. Müller *Asterias sanguinolenta*, and earlier known to Linck as *Pentadactylosaster oculatus*.

Brandt, as well as Düben and Koren, have already indicated the chief variations that occur in this Starfish—the former classifying them under the terms of varietas *macrodiscus* and v. *microdiscus*, and the latter authors as forma *major* and forma *minor* (*vulgaris*), each mentioning the main superficial characters that accompany the lengthening and shortening of the ray. Brandt records the short-armed variety from the west coast of the White Sea, and the long-armed one from the Ochhotsk Sea, near Chantar Island.

Distribution.

a. *Greenland*: Hare Island, Waigat Strait, lat. 70° 30′ N., 175 fms. (*'Valorous' Exped.*), the most northern locality on record; Egedesminde, 50 fms. (*Lütken*).

b. *North of American Continent*: Grand Manan (*Stimpson*); Massachusetts, Maine, and east coast of N. America.

c. *North of European Continent*: Spitzbergen (*Lütken*); Iceland, Færoe Islands, Scandinavia, and British coasts as far south as the English Channel; White Sea (*Brandt*).

d. *North of Asiatic Continent.*—Sea of Ochhotsk (*Brandt*).

Description of the Illustrations of this Species on Plate II.

Fig. 18. Abactinal aspect of the animal: natural size.
19. Actinal aspect of the same specimen: natural size.
20. Portion near the middle of a ray, actinal aspect: magnified.
21. Portion near the middle of a ray, abactinal aspect: magnified.

PEDICELLASTER PALÆOCRYSTALLUS, *Sladen.* Plate II, Figs. 22–26.

1877. *Asteracanthion palæocrystallus*, Sladen, Ann. & Mag. Nat. Hist. ser. 4, vol. xx. p. 455.
1880. *Pedicellaster palæocrystallus*, Sladen, Ann. & Mag. Nat. Hist. ser. 5, vol. v. p. 216.

In general appearance this Starfish bears strong resemblance to a small *Cribrella*, the rays, five in number, being round and tumid; they are long, somewhat swollen out on

the inner third, and taper considerably towards the extremity. The disk is small, its radius being proportional to an arm-radius as 1 : 5·5, or rather less. The ambulacral pores are well spaced, and form two simple rows of sucker-feet. Each adambulacral plate bears two very slender spines, one radiating towards the furrow and the other towards the margin, forming two regular rows of so-called "ambulacral" spines. The spines upon the sides of the arms are much shorter than the ambulacral spines, and comparatively more robust, being of the same size and character as the spinelets of the dorsal surface. The abactinal network is arranged more quadrilaterally than in *Asteracanthion*, a regular median line of ossicles passing down each ray, to which the other ossicles run parallel and transverse, with more or less regularity. A single spinelet is borne at each decussation, and an occasional one frequently on the intercalary ossicle. The spinelets are consequently widely spaced, and assume (although somewhat irregularly) a fairly rectilineal arrangement. These dorsal spinelets, which are all of the same shape and structure, resemble those of *Stichaster albulus*. They are deeply grooved, being formed, in fact, of three or more longitudinal lamellæ, which radiate from a common median axis. The extremity of the shaft becomes slightly expanded and truncate, and delicate denticles, developed from the free angles of the lamellæ, are present at the tip to the number of 3–5. In the ambulacral spinelets the outer margins of the lamellæ are serrate or denticulate, whereby, in these appendages, a thorny appearance is imparted to the shaft as well as to the tip.

The pedicellariæ are remarkably large and numerous, and thoroughly characteristic of the genus both in structure and position. One kind only is present, viz. the pedicellariæ forcipiformes, which are of extraordinary size, and but very little shorter than the dorsal spinelets; they stand isolated and alone upon the membranous tissue that covers the interspaces of the abactinal network, about three or four being present in each mesh. No traces of papulæ have been detected in the membrane of the dorsal interspaces of the examples under notice. The pedicellariæ increase in size in the neighbourhood of the ventral portion of the ray, the length of the calcareous skeleton of many of them measuring 0·35–0·375 of a millim.* The contour of the jaws of the pedicellariæ is considerably swollen out about the upper third, and then tapers rapidly towards the extremity, which is somewhat truncate. Several large curved denticles, usually three or four, occur upon the median portion of the inner margins. The tail-parts of the jaw-pieces are moderately long, and taper towards the extremity; and, when the pedicellaria is examined from above, the interlocking lips of the jaws are seen to be broad, rounded, and finely denticulate. Every appendage of the body, pedicellariæ and spinelets alike, is invested with a thick, semitransparent, cuticular membrane, to which is due the papillate appearance observable in specimens of the Starfish that are preserved in spirit. The spines are somewhat more crowded upon the disk than upon the rays; and the "eye"-spines at the extremities form a robust terminal fringe. The madreporiform plate, which is obscure and situated near the margin, bears only two or three striæ.

* The pedicellariæ on a young *Asteracanthion glacialis*, three or four times as large as the present specimen, do not measure more than 0·19–0·22 of a millim.

Size, Locality, and Colour.—The largest specimen we have examined measures 30 millims. in its greatest diameter, and 5·5 millims. across the disk. It was collected by Capt. Feilden in Discovery Bay (lat. 81° 41′ N.); depth 25 fathoms, hard bottom. Another example was dredged off Cape Frazer (lat. 79° 44′ N.), in 80 fathoms depth, which measures only 10 millims. in diameter, and is evidently a young specimen. The former of these Starfishes is dry, and in that state is of a dirty yellow or grey colour; the smaller one has been preserved in spirit, and is of a fawn-colour or light-brown shade.

Remarks.—The present species is undoubtedly a near relative of Sars's typical form, *P. typicus*, but clearly differs from it in general size, proportions, and habitus, as well as in the form of the pedicellariæ and spinelets. *P. palæocrystallus* is of larger size, and the length of the arm-radius, in proportion to that of the disk (about 5 : 1), is less than in *P. typicus*, in the largest examples of which it is $6\frac{1}{2}$ or 6 : 1. The contour of the arms is also different in our form, being more tumid on the inner third, and much more attenuated on the remaining outward portion of the ray. The dorsal spinelets are decidedly radio-laminate and somewhat expanded at the tip, instead of being conical, as described in *P. typicus*, and the shaft of the ambulacral spinelet is also denticulate or serrate. The pedicellariæ in the present species are even of relatively larger size, and differ in having the contour of the jaws considerably swollen out about the outer third, and then tapering rapidly towards the extremity, which is somewhat truncate. Indeed the general facies of the appendage is unmistakably distinct from that of the more southern form. (Compare Pl. II, Fig. 26, with figure given by Sars, *l. c.* pl. ix. figs. 15–17.)

Description of the Illustrations of this Species on Plate II.

Fig. 22. Abactinal aspect of the animal: natural size.
23. Actinal aspect of the same specimen: natural size.
24. Portion near the middle of a ray, actinal aspect: magnified.
25. Portion near the middle of a ray, abactinal aspect: magnified.
26. One of the pedicellariæ: magnified.

CROSSASTER PAPPOSUS (*Linck*), *Müller & Troschel.* Plate III, Figs. 1–4.

1733. *Triskaidecactis papposa*, Linck, De Stellis marinis, p. 43, tab. xxxii. no. 52, tab. xxxiv. no. 54.
1733. *Dodecactis reticulata in dorso*, id. *l. c.* p. 41, tab. xvii. no. 28.
1777. *Asterias helianthemoides*, Pennant, British Zoology, vol. iv. p. 66. no. 72.
1780. *Asterias papposa*, Fabricius, Fauna Grœnlandica, p. 369. no. 364.
1783. *Asterias papposa*, Retzius, K. Vet.-Akad. Handl. Stockholm, vol. iv. p. 230. no. 4.
1788. *Asterias papposa*, Gmelin, Syst. Nat. Linn. ed. xiii. p. 3160.
1816. *Asterias papposa*, Lamarck, Anim. s. Vert. ed. 1, vol. ii. p. 559. no. 22.
1821. *Asterias papposa*, Sabine, Parry's Journ. of a Voyage for the Discovery of a N.W. Passage &c., in 1819–20, Append. p. ccxxii.
1828. *Asterias papposa*, Ross, Parry's Narrative of Attempt to reach the North Pole in 1827, p. 202.
1828. *Asterias papposa*, Fleming, Hist. British Animals, p. 487.

1834. *Asterias* (*Solasterias*) *papposa*, Blainvillo, Manuel d'Actinologio, p. 241.
1834. *Asterias affinis*, Brandt, Act. Acad. St. Pétorsb. 1834, p. 271, et Prodr. Descr. anim. ab Mertensio obs., fasc. i. p. 71.
1834. ? *Asterias alboverrucosa*, id. ibid.
1835. *Stellonia papposa*, Agassiz, Prodr. Monog. Rad., Mém. Soc. Sci. Nat. Neufchâtel, t. i. p. 192.
1836. *Asterias papposa*, Johnston, Loudon's Mag. Nat. Hist. vol. ix. p. 474, fig. 69.
1839. *Solaster papposa*, Forbes, Ast. Irish Sea, Mem. Wern. Soc. vol. viii. p. 121.
1840. *Solaster* (*Polyaster*) *papposa*, Gray, Ann. & Mag. N. Hist. vol. vi. p. 183.
1840. *Crossaster papposus*, Müllor & Troschel, Wiegmann's Archiv, iv. pt. 1, p. 183.
1841. *Solaster papposa*, Forbes, Hist. British Starfishes, p. 112.
1842. *Solaster papposus*, Müller & Troschol, System der Astoriden, p. 26.
1852. *Solaster papposa*, Forbes, Suthorland's Journ. of a Voyage, vol. ii. Append. p. cexi.
1853. *Solaster papposus*, Stimpson, Invert. Grand Manan, p. 15.
1857. *Solaster papposus*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 40.
1862. *Solaster papposus*, Dujardin & Hupé, Hist. Nat. des Zooph. Échinodormes, p. 353.
1865. *Solaster papposus*, Norman, Ann. & Mag. Nat. Hist. ser. 3, vol. xv. p. 122.
1866. *Solaster* (*Polyaster*) *papposus*, Gray, Synop. Spec. Starf. Brit. Mus. p. 5.
1866. *Crossaster papposus*, Verrill, Proc. Boston Soc. Nat. Hist. vol. x. p. 345.
1871. *Solaster papposus*, Hodge, Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 134.
1875. *Solaster papposus*, Perrier, Stellérides du Muséum, p. 94; Arch. do Zool. exp. et gén. vol. iv. p. 358.
1877. *Crossaster papposus*, A. Agassiz, North-American Starfishes, pp. 98, 112.
1878. *Solaster papposus*, Viguier, Squeletto des Stellérides, Arch. de Zool. exp. et gén. vol. vii. p. 134.

A Starfish of depressed habit, having 10–15 rays, which are shorter than, or only equal to, the diameter of the disk, and taper uniformly to the extremities. The calcareous network of the abactinal surface is very widely spaced, and composed of a great number of small ossicles that overlap or imbricate upon one another; the intermediate meshes are consequently large, and the membranous skin which covers them frequently bears in the centre one or more isolated ossicles, round which the papulæ are grouped, not unfrequently 20–30 in number. Paxillæ, composed of a brush-like group of fine spinelets articulated on a rounded pedicle, are situated at each of the intersections, one being also occasionally present upon the line of plates that lies between, as well as upon, the isolated ossicles; their length is about equal to their distance apart, and in an adult specimen 20–30 spinelets occur in each fasciculus. The paxillæ stand moderately well spaced in consequence of the open character of the network, and, although there is no regularity whatever apparent in their arrangement upon the disk, a certain lineal disposition can be more or less clearly traced upon the rays. 10–12 paxillæ may be counted in a line drawn from the centre of the disk to an arm-angle, 15–20 from the tip of a ray to the base, and not more than 4 or 5 in an oblique row running from the median line of a ray up to the series of large marginal paxillæ. These lateral paxillæ, of which there is only a single series, are large and compressed, being two or three times the breadth of the dorsal paxillæ; they are widely spaced and placed obliquely, or even at right angles, to the median line, their direction being outwards and at an angle somewhat greater than 45° to the contour of the ray; midway between each of the large paxillæ is a small secondary paxilla, less than those of the dorsal surface. There are about 16 to 17 lateral paxillæ from the tip of the ray to the arm-angle.

Each adambulacral plate bears two series of spines: one upon the inner side,

running parallel with the furrow, and another, placed at right angles to this, forming a radiating comb, which holds a transverse position in relation to the direction of the ray. In the innermost or furrow series there are 3 to 4 spinelets to each plate, forming a line frequently more or less oblique and curved in its position; and their length at the base of the ray is fully equal to two thirds of the breadth of the furrow at its widest part. In the transverse series, the spinelets, which are 5–7 in number, are connected at their base by a membranous skin; they are stout, and the innermost spines are somewhat larger than those of the longitudinal series.

The interbrachial spaces are very narrow, and either entirely naked or bearing only a few small spine-groups resembling rudimentary papillæ, irregularly disposed here and there.

The mouth-plates are broad and subtriangular, having a marginal fringe of large robust mouth-spines upon their outer edges; the four or five innermost, which are directed towards the actinostome, diverge only slightly from one another; whilst the following five or six, which are somewhat smaller, radiate sideways, and interlock more or less deeply with those of the neighbouring mouth-plate. From the surface of each mouth-plate, and standing perpendicularly thereto, midway between the outer edge and the median suture, is a secondary series of two or three large robust spines.

Size.—Large examples are on record measuring 280 millims. in diameter; but the northern specimens are usually very much smaller, seldom exceeding 100–150 millims., the largest individual from Discovery Bay being only 93 millims.

Colour.—According to Lütken the Greenland specimens are generally of a deep fiery red; but in the more southern portion of its area of distribution the species is frequently more or less mottled with lighter shades, whilst the general tint is often inclined to shades of purple. Small examples are white or straw-coloured. All colour is usually bleached in specimens preserved in spirit.

Habitat.—*C. papposus* frequents a hard-ground locality, its bathymetrical range extending from low water to great depths, as indicated in the citations of occurrence given below.

Premature Form.—In a young stage the ossicles of the abactinal network are more widely spaced, and consequently the paxillæ, which at this age are only found at the intersections, stand further apart and are fewer in number; whilst the paxillæ, although composed of a smaller number of spinelets, are proportionately larger in size when compared with those on the adult Starfish. The large compressed lateral paxillæ are fewer in number, as are also the papulæ. Consequent on the smaller number of ray-elements there are fewer transverse ambulacral combs; and these themselves are made up of only 3–5 spinelets (the number varying according to age), whilst not more than two spines of the longitudinal furrow-series are present. The mouth-spines are, in like manner, less striking, both in character and number.

Variations.—The variations which are the most strikingly conspicuous in this species are those that affect the relative proportions of the rays to the disk and the character of the dorsal paxillæ. Dr. Lütken * has already remarked on the existence

* Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 42.

of a long-armed variety, in which the rays are flatter and more pointed, and the paxillæ smaller but more numerous. Examples of a similar form occurred in the collections made during the British Arctic Expedition of 1875–76; and there may also be noted in these specimens an increase in the number of lateral paxillary combs concurrent with the greater length of the ray.

The number of rays is also subject to variation, the presence of ten especially seeming to bear a locational significance. Only one example from Greenland is cited by Lütken; but amongst the specimens collected in the extreme north by the naturalists of Captain Nares's Expedition (mentioned above) this number of rays was the general rule.

It would seem probable that the two species established by Brandt under the names of *Asterias affinis* and *A. alboverrucosa* should be ranked in the present category, since the characters upon which the specific individuality of these forms is based are, excepting the number of radii, only those which accompany early phases of growth; and this fact, together with the small size of the recorded type (disk 1 inch in diam.), would go far to warrant the conclusion that (in the case of *affinis* at least) Brandt's species is nothing more than the young stage of the northern ten-armed form of *C. papposus*. The description given in the 'Prodromus Descrip. animalium &c.' is itself so brief, that it furnishes no features upon which a contrary opinion can be maintained; but at the same time the statement should not be lost sight of that the diagnosis was founded not upon an actual specimen, but only upon a drawing by another hand. Obviously, therefore, no great reliance upon the determination can be accorded by, or even be expected of, posterity in such a case.

In the recently published memoir by MM. Danielssen and Koren on the Echinodermata of the Norwegian North-Atlantic Expedition*, two specimens of *Crossaster* are referred to this obscure species of Brandt's (*A. affinis*) and carefully described (*l. c.* p. 57). It would seem to us, however, that the details there cited may, with perhaps only a single exception, be shown to occur in forms which can be traced through all the stages of variation up to the undoubted typical *C. papposus*, and not unfrequently even in British examples of the species.

One very marked peculiarity, however, is noted in the description above referred to, and which consists in the great number of spinelets present in the series on the furrow side of each adambulacral plate, viz. seven (or even eight rarely); whilst in large specimens of *C. papposus* it is very seldom that more than four occur, and similarly in the northern ten-armed specimens from Discovery Bay. Such a divergence is very remarkable. The number of spinelets in the transverse comb is also greater (8–10) than generally obtains in *C. papposus* of similar size.

Balancing the whole evidence, however, it would appear very doubtful whether the divergence is greater than might be expected in a locational or deep-sea variety, and which we should greatly question the propriety of separating as an independent species from *Crossaster papposus*. The specimens were dredged in lat. 64° 35′ N., long. 10° 20′ W., 290 fathoms.

* Nyt Mag. f. Naturvidensk. 1877, Bd. xxiii. 3, p. 45.

Sir Wyville Thomson likewise records the presence of a ten-armed variety in the Færoe channel at a depth of 610 fathoms, but gives no details of its characters.

A variation of secondary importance occurs in the character of the paxillæ, by the length of the spinelets of the crown being sometimes reduced to extreme shortness, and thereby imparting to the paxillæ the appearance of small granulate cones. This condition, however, is in a great measure the result of abrasion, and is dependent consequently upon the special nature of the locality; thus a Starfish inhabiting the comparative calms of deep water would be subject to much less friction than one frequenting a littoral district or amongst pebbly shingle.

The interbrachial spaces are also liable to change, being sometimes quite naked, whilst in other cases they are more or less filled with paxillary spinulation.

Distribution.

a. *Northward up Smith Sound*: Discovery Bay, lat. 81° 41′ N., 25 fms., hard bottom (*Nares's Exped.*), the most northern locality on record; Cape Frazer, 80 fms.; Franklin-Pierce Bay, 15 fms., bottom temperature 29°·5 Fahr.

b. *North of American Continent*: Assistance Bay (*Penny's Exped.*), Newfoundland (*Verrill*), Grand Manan (*Stimpson*), Massachusetts (*Verrill, Gould, &c.*).

c. *North of European Continent*: Spitzbergen (*Lütken*); Barents Sea, lat. 76° 58′ N., long. 45° 40′ E., 110 fms. (*'Willem Barents' Exped.*); Finmark, Scandinavian coasts, Iceland, Færoe Islands (*Lütken*); British coasts; French coast as far as the dept. of Finisterre (*Lütken*).

d. *North of Asiatic Continent*: Behring's Straits? (under the name of *A. affinis*, Brandt).

Description of the Illustrations of this Species on Plate III.

Fig. 1. Abactinal aspect of a young specimen.
2. Actinal aspect of the same specimen: natural size.
3. Portion near the middle of a ray, actinal aspect: magnified.
4. Portion near the middle of a ray, abactinal aspect: magnified.

SOLASTER ENDECA (*Gmel.*), *Forbes*. Plate III, Figs. 5–8.

1776. *Asterias aspera*, O. F. Müller, Zool. Dan. Prodr. p. 234. no. 2833.
1788. *Asterias endeca*, Gmelin, Syst. Nat. Linn. ed. xiii. p. 3162.
1816. *Asterias endeca*, Lamarck, Anim. s. Vert. vol. ii. p. 560. no. 23.
1828. *Asterias endica*, Fleming, Hist. British Animals, p. 487.
1834. *Asterias* (*Solasterias*) *endeca*, Blainville, Manuel d'Actinologie, p. 241.
1835. *Asterias endeca*, Johnston, Mag. Nat. Hist. vol. ix. p. 300, fig. 44.
1835. *Stellonia endeca*, Agassiz, Mém. Soc. Sci. Nat. Neufchâtel, vol. i. p. 192.
1839. *Solaster endeca*, Forbes, Mem. Wern. Soc. vol. viii. p. 121.
1840. *Solaster* (*Endeca*) *endeca*, Gray, Ann. & Mag. Nat. Hist. vol. vi. p. 183.
1841. *Solaster endeca*, Forbes, Hist. British Starfishes, p. 109.
1842. *Solaster endeca*, Müller & Troschel, System der Asteriden, p. 26.

1853. *Solaster endeca*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 14.
1857. *Solaster endeca*, Lütkon, Vid. Meddel. N. Ferening i Kjöbenhavn, 1857, p. 35.
1861. *Solaster endeca*, Sars, Oversigt af Norges Echinodermer, p. 75.
1862. *Solaster endeca*, Dujardin & Hupé, Hist. Nat. Zeoph. Échinodermes, p. 254.
1865. *Solaster endeca*, Norman, Ann. & Mag. Nat. Hist. ser. 3, vol. xv. p. 122.
1866. *Solaster* (*Endeca*) *endeca*, Gray, Synop. Spec. Starf. Brit. Mus. p. 5.
1866. *Solaster endeca*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. pp. 345, 356.
1871. *Solaster endeca*, Hedge, Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 135.
1875. *Solaster endeca*, Perrier, Stellérides du Muséum, p. 95; Arch. d. Zool. exp. et gén. vol. iv. p. 359.

Rays 8–11 in number, in length equal to, or only a little longer than, the diameter of the disk. The disk is high and considerably arched, the rays being consequently very deep at their base, with sides almost vertical, which gives an appearance of lateral compression; they taper rapidly towards the tip, however, and become round or subcylindrical in shape. In the median interradial line, at the junction of neighbouring rays, there is often a slight depression or furrow, which imparts a very graceful appearance to the Starfish. The abactinal calcareous network is very compact, the interspaces being small and constricted. In large-sized specimens, each of the meshes upon the disk and upper portion of the rays usually contain two (and occasionally three) papulæ, but seldom more than one is present in small examples, and towards the extremities of the rays. A paxilla or small tuft of spinelets (5 to 10 in number) springs from each intersection, and these form regular parallel lines running obliquely from the margin to the median line of the ray, in consequence of the symmetrical character of the calcareous network and the diagonal arrangement of the ossicles across the ray, 10–12 paxillæ being counted in such a row at the extreme base of the ray.

The periproct is central and prominent, and the madreporiform tubercle is situated in an interradium midway between the centre and the arm-angle. There are two rows of ventro-marginal paxillæ, those of the upper series, although larger than the general dorsal paxillæ, being very much smaller than those of the companion ventral series.

The paxillæ of the lower series are large and compressed in form; the lateral expansion of the pedicle exceeds the thickness by seven or eight times, and the longer axis is placed at right angles to the median line of the ray. 40–50 of these large paxillæ extend between the tip of the ray and the arm-angle; the series is situate quite over on the ventral surface, and runs with a curve round the margin of the arm-angle, forming a continuous series with those from the neighbouring ray. The paxillæ which bound the interradial area are very much smaller than those which occur upon the rays proper.

Each adambulacral plate bears two sets of spines:—One a small series, placed very high up in the furrow and running parallel with it, which consists of two or three small spines, the aboral being largest; the other series forms a fan-like comb of six or seven spines, connected by a membranous web, and is borne upon an elevated keel at right angles to the furrow, almost concealing the small marginal series, which is placed deep within the groove. The spinelets of the transverse series gradually increase in size as they approach the furrow.

The interbrachial space, which is elongate, narrow, and sagittiform in contour, is

occupied by a number of small paxillæ, less than those of the dorsal surface, and seldom, except in largely grown specimens, bearing more than five or six spinelets, and all of a compressed, flat, comb-like form. The paxillæ are regularly arranged and closely placed within the area, but only extend for a short distance along the ray, gradually becoming rudimentary as the space between the "ambulacral" transverse combs and the marginal series of paxillæ diminishes.

The mouth-plates are large and somewhat spatuliform, having an armature arranged after the following manner:—The two innermost mouth-spines are long, stout, and directed towards the centre of the peristome; then follow a series of about six or seven spines placed at regular intervals apart, which radiate in the plane of the plate, one after the other, at an increasing angle from the median line. The two most adoral mouth-spines are much longer proportionally than the rest, which gradually diminish in size as they approach the radial series, and being likewise curved somewhat upward from the plane of the mouth-plate, cross and interlock with the corresponding spines of the neighbouring mouth-angle. Between the outer margin of the mouth-plate and the side that falls in the median line of the ray runs a more or less definite keel, upon which is borne a secondary series of seven or eight spinelets, forming a modified comb that stands almost perpendicular to the plane of the mouth-plate, and runs parallel with the marginal series or mouth-spines proper, above described.

Size.—Sars mentions an unusually large example measuring 330 millims.; but the ordinary size seldom exceeds 200 millims., whilst the northern forms are usually much less; thus at Tromsö 80 millims., and at Florö 100 millims. (*Sars*).

Colour.—Shades of red varying to purple on the upper surface and cream-colour beneath. Occasionally in preserved specimens a trace is left of the natural red colour. According to Verrill, this species is, in the Bay of Fundy, usually deep purple above and orange below; one large example occurred entirely orange.

Habitat.—On stony or sandy bottoms, from low-water mark down to 90 fms. (*Lütken*).

Premature Form.—In young ten-armed examples from Greenland, 10 millims. in diameter, described by Lütken, the arms are remarkably short ($2\frac{1}{2}$ millims.), and the dorsal surface is pretty closely covered with groups of 4–6 spinelets, these immature paxillæ being proportionally large and few in number when compared with those on the mature animal. Bordering the margin of the ray there are about eight paxillæ that separate the dorsal and ventral surfaces, but do not, as in the case of older stages, lay entirely on the ventral area. Along each side of the furrow is a series of about 14 of the transverse "ambulacral" combs, each of four spinelets. The ventral interbrachial areas are still quite small, and have only very few spinelets. Each mouth-plate bears four spines, of which the innermost is longest and is directed horizontally towards the centre of the mouth-opening. The papulæ and the spinelets composing the paxillæ increase in number with age.

We have been enabled to confirm the tenour of these observations by a small individual dredged by Captain Feilden, during the outward voyage of the British Arctic Expedition, in lat. 65° N., 26 miles from the coast of Greenland, at a depth of 30 fms.,

bottom rocky with rounded pebbles. This example is nine-armed, and measures 14 millims. across its greatest diameter, R=7 millims., r=3 millims., the length of the arm from the tip to the arm-angle being rather less than 4 millims. The ventro-lateral series of paxillæ are about twelve in number on each side of the ray and quite marginal, instead of being entirely on the ventral surface as in older forms. There are about twenty of the transverse "ambulacral" combs between the extremity of the ray and the mouth-plate, each composed of four spines. Each mouth-plate carries four spines on its margin, which gives eight to the mouth-angle, and there are about two or three of the inner secondary series present. The dorsal paxillæ upon the disk are composed of four to six spinelets, but those on the rays have seldom more than three.

Variations.—This species on the whole would seem to be very fairly constant in character, although considerable variation is manifest in the number of rays. Brandt * notes a ten-armed variety from Sitcha; and seven-, eight-, and nine-armed forms are cited by Lütken. The last-named observer also records a variety, taken in Iceland, Floröen, and Greenland †, in which the rays are blunter and coarser, as well as more uniform in thickness throughout their length, and in which the paxillæ of the ventral interbrachial spaces are more compressed and carry a greater number of spinelets (10–20). With our present information, however, it is difficult to say what claim these modifications have upon our recognition.

Distribution.

a. *Greenland*: up to lat. 70° N., Omenak (*Lütken*), being the most northern locality on record; Davis Straits, lat. 67° 50′ N., long. 55° 27′ W., 20 fms., bottom of broken barnacles and shells (*'Valorous' Exped.*); lat. 65° N., 30 fms., rocky bottom (*Nares's Exped.*).

b. *North of American Continent*: Newfoundland (*Lütken*); St. George's Bank, 25 fms. (*Verrill*); Grand Manan (*Stimpson*); Fundy Bay and Maine, low-water mark down to 20 fms. (*Verrill*).

c. *North of European Continent*: Finmark, Tromsö (*Lütken*); Iceland (*Lütken*); Færoe Islands; British Isles to S. of Ireland and the Channel.

d. Sitcha (*Brandt*).

Description of the Illustrations of this Species on Plate III.

Fig. 5. Abactinal aspect of the animal: natural size.
6. Actinal aspect of the same specimen: natural size.
7. Portion near the middle of a ray, actinal aspect: magnified.
8. Portion near the middle of a ray, abactinal aspect: magnified.

LOPHASTER FURCIFER (*Düben & Koren*), *Verrill*. Plate III, Figs. 9–12.

1844. *Chætaster borealis*, Düben, Œfv. Kongl. Vet.-Akad. Förhandl. 1844, p. 113.
1844. *Solaster furcifer*, Düben & Koren, Kongl. Vet.-Akad. Handl. 1844, p. 243, pl. vi. figs. 7–10.
1862. *Solaster furcifer*, Dujardin & Hupé, Hist. Nat. Zooph. Échinodermes, p. 355.
1878. *Lophaster furcifer*, Verrill, Amer. Journ. Sci. & Arts, ser. 3, vol. xvi. p. 214.

* Prodr. Descrip. animalium &c. p. 71. † Vidensk. Meddelelser for 1857, p. 38.

A Starfish of rather depressed form, having five broad flat arms; the proportion of the greater to the lesser radius being about 3 : 1 approximately. The calcareous skeleton of the abactinal surface forms a very regular network, and the large conspicuous paxillæ that spring from the intersections form longitudinal series which run parallel to the median line of the ray; consequently only two or three of the middle rows reach to the tip, although from fourteen to sixteen may be counted at the base of the arm. The paxillæ, which are very compact, have a remarkably large stout pedicle nearly twice as wide as high, and bear a crown of spinelets, numbering from fifteen to twenty, or even more in large specimens, in length about equal to the diameter of the base. The spinelets are flat in young examples, and from the angles of their apex, which is as broad or broader than the base, proceed two small denticles, giving to the spinelet the appearance of a two-pronged fork; with increasing age, however, the spinelets become multilaminate, and the number of apical denticles corresponds with that of the laminæ, which radiate from the median axis of the spinelet.

The papulæ are in groups of from four to ten or twelve in number, varying according to age and size. They are most numerous upon the disk, the interspaces between the ossicles of the calcareous network being smaller further out upon the rays, where the papulæ are consequently fewer and the paxillæ closer together.

The sides of the rays are deep and perpendicular, and are bounded by a dorsal and a ventral series of marginal paxillæ; they stand wide apart from one another, and are about twenty (17–22) in number from the arm-angle to the extremity of the ray. The paxillæ of the dorso-lateral series are larger than the general paxillæ of the dorsal area, and are directed somewhat upwards. The ventro-lateral series, which are much larger and very prominent, alternate with these, standing opposite to the interspaces, and are directed at an angle downwards; their pedicles are nearly twice as broad as the foregoing and oval in section, whilst the spinelets attached to them are somewhat shorter than those on the dorsal paxillæ. There are no paxillæ in the space between the dorsal and ventral series above named, the sides of the rays being bare.

Each adambulacral plate bears two series of spinelets: one which runs parallel to the furrow, and is composed of three to five equal-sized spinelets; and a transverse series of three or four placed obliquely or even at right angles to the furrow-series, a thick membrane uniting the spinelets and forming a webbed comb.

The ventral interbrachial areas are large, and bear a number of paxillæ arranged in rows parallel with the furrow, two, three, or sometimes even more of such rows being present. In the largest example we have examined the innermost row has eleven or twelve paxillæ extending from the median interbrachial line out along the ray; the next outermost numbers 5, the third 3, the angle thus left being filled up by a solitary paxilla. The paxillæ are large and all covered with a thick membrane; their bases or pedicles are very short, and carry six to eight spinelets arranged somewhat like a double fan, all radiating and directed outwards. The main group of paxillæ which stand upon the area are nearly equal in size, but the five or six most aboral ones of the innermost row diminish in size as they recede from the mouth; they do not extend

beyond one third of the length of the ray, and the most outward ones are made up of only three or four small spinelets, not sufficient to form a paxilla proper.

The mouth-plates are large and broad, and the marginal spines interlock with those of the neighbouring mouth-angle.

The madreporiform tubercle is small and often difficult to find, being almost hidden by paxillæ; it is situated a little nearer to the centre than midway between that point and the arm-angle, and in some specimens it stands at about one third the distance.

Size.—The greater radius of the three specimens known to Düben and Koren measured respectively 30, 16–18, and 11 millims.; the specimens from Cape Frazer are somewhat larger than this, whilst those from Discovery Bay measure 82 and 53 millims. in their greater radius. The largest of the Cape-Frazer specimens is about 32 millims. in the greater radius, 65 millims. in its greatest diameter, and 21 millims. across the disk, the arms at their base being 13 millims. broad.

Colour.—According to Düben and Koren, the colour of the living animal is brick-red above and white beneath; the eye-spots bright red.

Habitat.—Although no actual record has been preserved of the nature of the ground inhabited by this Starfish in the far north, a certain amount of incidental evidence is furnished by the fact that the smaller of the two specimens from Discovery Bay has its stomach filled with the remains of *Antedon*, and upon which it had evidently taken its last meal! In all probability they were fellow residents on the same sea-bed.

Variations.—Under this head should be recorded a specimen obtained by Mr. Hart in Discovery Bay during the British Arctic Expedition of 1875–76, and which we have included within the present species only after much hesitation. The greater radius of this example measures 82 millims., the lesser 30 millims. The arm-angles are much more rounded, and the rays comparatively much broader at the base and more rapidly tapering (being remarkably attenuated towards the extremity) than in smaller forms with which we have previously been acquainted. By this means an extremely broad character is imparted to the disk, and a contour altogether different from that given by Düben and Koren and by Sir Wyville Thomson in figures of *Solaster furcifer*. The present specimen is also noteworthy from the great number of papulæ that are present; in fact so numerous are they, that the dorsal paxillæ have the appearance of springing from quite a forest of these tubelets, whilst the degree to which every appendage of the body is invested with membrane, and all the ventral spinelets webbed together, tends to produce a character which, although superficial, is remarkably striking and conspicuous.

At first sight it would seem that these modifications should be considered marks of specific distinction; and such *per se* the writers would have been disposed to regard them, had not a second (and smaller) specimen, likewise obtained in Discovery Bay, furnished a phase of gradation between this apparently independent form and examples of the same species dredged off Cape Frazer by Capt. Feilden—the larger of these latter presenting a stage which diverges from the ordinary form (as diagnosed by Düben and Koren) in the direction of the above-named specimen.

We are still much in ignorance as to the changes undergone by *L. furcifer* during growth, whilst the records of its occurrence and structure are so few, that we prefer for the present to regard the specimens from Discovery Bay as largely developed examples of the species under notice, rather than to place them as independent forms, from such scanty material.

Distribution.

a. *Northward up Smith Sound*: Discovery Bay, lat. 81° 41′ N. (*Nares's Exped.*), the most northern locality on record; Cape Frazer, 80 fms.

b. *North of American Continent*: George's Bank, Gulf of Maine, 150 fms. (*Verrill*).

c. *North of European Continent*: Bergen, 30–50 fms. (*Sars, Düben and Koren*).

Description of the Illustrations of this Species on Plate III.

Fig. 9. Abactinal aspect of the animal: natural size.
10. Actinal aspect of the same specimen: natural size.
11. Portion near the middle of a ray, actinal aspect: magnified.
12. Portion near the middle of a ray, abactinal aspect: magnified.

PTERASTER MILITARIS (*O. F. Müller*), *M. & T.* Plate III, Figs. 13–16.

1776. *Asterias militaris*, O. F. Müller, Zool. Dan. Prodr. p. 234. no. 2828.
1788. *Asterias militaris*, Gmelin, Syst. Nat. Linn. ed. xiii. p. 3160.
1806. *Asterias militaris*, Rathke, Zool. Dan. vol. iv. p. 13, tab. 131.
1842. *Asteriscus militaris*, Müller & Troschel, System der Asteriden, p. 44.
1842. *Pteraster militaris*, Müller & Troschel, System der Asteriden, p. 128, tab. vi. fig. 1.
1844. *Pteraster militaris*, Düben & Koren, Kongl. Vet.-Akad. Handl. 1844, p. 246, tab. vii. figs. 11–13.
1850. *Pteraster militaris*, Sars, Nyt Mag. f. Naturv. vol. vi. p. 161.
1853. *Pteraster militaris*, Stimpson, Invert. Grand Manan, p. 15.
1856. *Pteraster militaris*, Sars, Koren, & Danielssen, Fauna litt. Norv. Heft 2, p. 55, tab. vii. figs. 1–8.
1857. *Pteraster militaris*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 43.
1861. *Pteraster militaris*, Sars, Oversigt af Norges Echinodermer, p. 48.
1862. *Pteraster militaris*, Dujardin & Hupé, Hist. Nat. Zooph. Échinodermes, p. 434.
1866. *Pteraster militaris*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 355.
1871. *Pteraster militaris*, Verrill, Trans. Connect. Acad. A. & S. vol. i. p. 569.
1875. *Pteraster militaris*, Perrier, Stellérides du Muséum, p. 381; Arch. d. Zool. exp. et gén. vol. v. p. 301.

This Starfish is readily distinguished by the singular fin-like margin surrounding the rays, and by the membranous skin which is supported over the upper surface of the test, as well as by the largely-developed series of webbed spines that resemble fans placed on the adambulacral plates at right angles to the direction of the furrow.

The contour of the present species is pentagonal, the body being high and arched and the underside flat. Proportion of disk-radius to arm-radius 1 : 2. The ossicles of the abactinal skeleton are subcruciform, and suggest fancifully the idea of a St. Andrew's cross. The major diameter of these plates lies in the direction of the ray, and their prolongations imbricate upon corresponding parts of neighbouring

ossicles, whereby it follows that the intermediate spaces are suboval or diamond-shaped, and an apparent diagonal arrangement of calcareous plates is produced. Each of the cruciform ossicles bears a single paxilla situated on the margin of the angle that lies nearest to the centre of the disk. The pedicle of the paxilla is short, usually little more than a tubercle, and bears three or sometimes four comparatively long tapering spinelets; these diverge at a small angle from one another, and are maintained in this position by numerous extremely fine muscular fibres, which are attached near the tips, and pass from spine to spine in every direction over the entire area. By this means the foundation is laid for a membranous tissue, which is supported over the body like a tent-cloth by the spinelets, and by which the whole dorsal surface of the animal is covered and concealed. A hollow infradermal cavity is thus formed, wherein the development of the ova and embryos takes place*. Each of the intermediate spaces or meshes in the calcareous network of the skeleton has a single puncture in its membrane near the base of the paxilla, which gives passage to a papula of very peculiar form. This remarkable organ, instead of being cylindrical with a simple conical tip, as is usually the case, has its extremity split up into a number of short blind cæca or knob-like branchlets, and is attached to the base of the paxilla, being in all probability non-retractile.

Each adambulacral plate bears a transverse series of five or six long spines, which are connected together by a membrane, and form a webbed fan that stands at a right angle to the ambulacral furrow. The outermost spine of each comb is double the length and thickness of any of the others, but does not always stand in a line with the rest of the fan-like series, being sometimes nearly midway between its own series and the next succeeding; the other spines of the "ambulacral" comb are nearly equal in size, the middle ones being slightly longer. The long external spines above named extend about half their length beyond the edge of the ray, and are united to one another by a connecting-tissue, which forms the fan-like fringe that surrounds the entire Starfish; and this also is the boundary of the secondary or supradermal covering of the dorsal surface before described. The mouth-plates are subquadrate in form; and the mouth-spines, which are 5 or 6 in number, are webbed together and directed at an angle downwards, the innermost spinelet being the longest and stoutest of the series. From the centre of each mouth-plate, and standing perpendicular to its plane, is a very large stout spine, much thicker and larger than any of the others; this is articulated on a small rudimentary tubercle, and has the tip, which is abruptly pointed, transparent and glass-like.

The anal aperture is situated at the centre of the inner or true dorsal surface of the animal; and the madreporiform body, which is circular and more or less arched and granulate or tubercular in appearance, lies in a median interradial line near to the centre, and not more than its own diameter away from the periproct. A moderately wide orifice, surrounded by a circlet of enlarged paxillæ, is situated in the centre of

* For details consult Koren and Danielssen, Fauna litt. Norv., Heft 2, p. 58; Sars, Oversigt af Norges Echinodermer, p. 58.

the dorsal area of the upper investing membrane, and this forms the common oscular entrance to the cavity, and stands immediately over the anal aperture. Other openings into the infradermal cavity occur upon the abactinal surface between each of the long lateral spines, the apertures being guarded (and can also probably be closed) by a modified spinelet or scale-papilla articulated on the body-frame. There are also a number of small circular punctures distributed over the membrane, which Sars referred to under the style of *spiracula*, and according to whose observations they are surrounded with a sphincter muscle that would, in all probability, enable them to be opened and closed at will. The superficial dermal covering contains a number of very fine calcareous spicules, and the projecting tips of the supporting paxillary spinelets produce fine asperities over its surface.

Size.—The northern specimens would appear, according to Sars's observations, to be larger than those occurring in the southern portion of the area of distribution. Those taken at Finmark reach the size of 3 inches, whilst specimens from the neighbourhood of Bergen seldom exceed $1\frac{1}{2}$–2 inches; the largest size on record is 4 inches (*Lütken*).

Colour.—Sars remarks that the colour of this species is tolerably variable, the dorsal surface being snow-white, yellowish white, or pale reddish flesh-colour, with a round blood-red eye-spot at the tip of the arm, and the ventral surface of the animal always white. The same author cites a small example from Finmark which was straw-coloured, the tips of the rays orange, a few small scattered spots of the same colour upon the dorsal surface, and the oscular aperture in the centre being also margined with orange. Larger examples from the same coast presented the variations above noted in comparison with specimens from Bergen.

According to the 'Zoologia Danica,' the animal is more of a brick-red, which colour Lütken also states to have been retained in a large specimen sent to the Copenhagen Museum by Capt. Holböll.

Habitat.—This Starfish occurs in 40–60 fms. depth at Bergen, and 20–100 fms. off the coast of Finmark; in 35 fms. off Grand Manan, shelly bottom (*Stimpson*).

Premature Stages.—We are unfortunately not able to furnish any information upon the characters presented by this species after it has passed the embryonic stage, and prior to the assumption of the adult features. Sars, and also Koren and Danielssen*, have, however, made very valuable observations upon the earlier phases, the two last-named having traced the development of the egg, whilst Sars† gives very admirable descriptions and figures of the later stages of the larval form. Four of these were found in the infradermal cavity of a specimen $\frac{7}{8}$ inch in diameter from Tromsö; and twelve young, along with two or three eggs, in one 3 inches in diameter from Vadsö. In the young individual of $1\frac{1}{2}$–$1\frac{3}{4}$ millim. in diameter, the pentagonal form is already apparent, and three pairs of sucker-feet, together with the odd terminal tentacle, are present in each of the radii. In the place of the actinostome there is a large hemispherical protuberance or knob-shaped body, equal to nearly one third of the animal's

* Fauna littoralis Norvegiæ, Heft 2.

† Oversigt af Norges Echinodermer, pp. 58–62, pl. vi.

diameter, the still unresorbed remains of the larva-body; and there is yet no trace of the future mouth-opening. Upon the dorsal surface, and surrounding the centre, are five large tubercular prominences or wart-like knobs of the body-skin, which Sars regarded as the rudiments of the perianal paxillæ; and two similar bodies occur at the margin of each radius, one on either side of the median line, double the size of those just mentioned and oval in outline, which would seem to be primitive paxillæ, or rather the skin-like sheaths in which these are ultimately formed. No opening was to be found on the centre of the dorsal surface, nor any trace of the calcareous formations of the future Starfish.

Distribution.

a. *Northward up Smith Sound*: Dobbin Bay, lat. 79° 40′ N., 30 fms. (*Nares's Exped.*), the most northern locality on record.

In Davis Strait: lat. 67° 50′ N., long. 55° 27′ W., 20 fms. (*'Valorous' Exped.*).

b. *North of American Continent*: Grand Manan (*Stimpson*); Bay of Fundy, 35 fms., shelly bottom (*Verrill*).

c. *North of European Continent*: Spitzbergen (*Lütken*); Finmark (*Sars*); Hardanger Fjord in Norway, the southern limit known to Sars.

Description of the Illustrations of this Species on Plate III.

Fig. 13. Abactinal aspect of the animal: natural size.
14. Actinal aspect of the same specimen: natural size.
15. Portion near the middle of a ray, actinal aspect: magnified.
16. Portion near the middle of a ray, abactinal aspect: magnified.

CTENODISCUS CORNICULATUS (*Linck*), *Perrier*. Plate III, Figs. 17–20.

1733. *Astropecten corniculatus*, Linck, De Stellis marinis, p. 27, tab. xxxvi. no. 63.
1805. *Asterias crispata*, Retzius, Dissert. sist. species cognitas Asteriarum, p. 17.
1821. *Asterias polaris*, Sabine, Parry's Journ. of a Voyage for the Discovery of a N.W. Passage &c. in 1819–20, Append. p. ccxxiii, pl. i. figs. 2, 3.
1834. *Asterias auranciaca*, Dewhurst, Nat. Hist. of the Order Cetacea, p. 283.
1840. *Astropecten polaris*, Gray, Ann. & Mag. Nat. Hist. vol. vi. p. 180.
1842. *Ctenodiscus polaris*, Müller & Troschel, System der Asteriden, pp. 76 et 129.
1842. *Ctenodiscus pygmæus*, id. ibid. p. 76.
1844. *Ctenodiscus crispatus*, Düben & Koren, K. Vet.-Akad. Handl. 1844, p. 253.
1852. *Ctenodiscus polaris*, Forbes, Sutherland's Journ. of a Voyage, vol. ii., Append. p. ccxiv.
1853. *Ctenodiscus crispatus*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 15.
1857. *Ctenodiscus crispatus*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 45.
1861. *Ctenodiscus crispatus*, Sars, Oversigt af Norges Echinodermer, p. 26.
1862. *Ctenodiscus crispatus*, Dujardin & Hupé, Hist. Nat. Zooph. Échinodermes, p. 431.
1866. *Astropecten polaris*, Gray, Synop. Spec. Starf. Brit. Mus. p. 3.
1866. *Ctenodiscus crispatus*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. pp. 345 and 356.
1869. *Anodiscus* (= *Ctenodiscus*) *rispatus*, Perrier, Rech. sur les Pédicell. et les Ambul. p. 106.

1875. *Ctenodiscus corniculatus*, Perrier, Stellérides du Muséum, p. 380; Arch. de Zool. exp. et gén. p. 300.

1879. *Ctenodiscus corniculatus*, Viguier, Squelette des Stell., Arch. de Zool. exp. et gén. t. vii. p. 226.

Body depressed and goniodiscoid in outline; radii five in number, with the arm-angles well rounded; proportion of greater to lesser diameter 2 : 1. The calcareous elements of the abactinal surface form a compact network, similar to *Astropecten*, in which the interspaces are but very small. A great number of small closely-placed paxillæ are borne upon this framework, each carrying 5–10 round, blunt spinelets, the whole so densely crowded together that the spinelets are normally directed upward from the pedicle. The abactinal surface is frequently puffed up and more or less convex in profile (owing probably to the quantity of sand or clay with which this Star-fish fills its stomach); whilst a small peak-like protuberance rises from the centre, around which the paxillæ rapidly diminish in size. The sides of the disk are perpendicular, and formed of two series of marginal plates—one ventral, the other dorsal. Each dorsal plate is ankylosed to a corresponding ventral plate—the pair thus formed being separated from the neighbouring pair on either hand by a deep furrow, which follows the lateral suture of the plates, the margins being fringed with a series of fine, compressed, cilia-like spinelets, which arch over the furrow. Each of the dorso-lateral plates bears a small compressed, but pointed, spinelet, which stands erect on its upper margin; and the lower or ventro-lateral series likewise carry a similar spinelet, which is placed near the junction of the ventral and dorsal plates, and projects at right angles to the side walls of the test. The last or terminal dorso-lateral plates of each side of a ray are ankylosed together, and form a large arched or tubercular plate, indented on its outer margin, and bearing three more or less prominent tubercles—the rudiments of dorso-marginal spines. The furrows between the marginal plates are continued onto the actinal surface of the animal and extend to the ambulacral furrow, cutting up the ventral interradial areas into band-like spaces, each of which is tessellated with irregular, subquadrate, scale-like plates that imbricate upon one another, and form normally, in large adult examples, a double alternating series behind each adambulacral plate. The innermost band, however, of each area comprises two adambulacral plates; and the trapezoid tessellating scales, which here always form a regular double alternating series, are, in consequence, twice as large in the neighbourhood of the furrow as the scales in the other bands. All these plates bear on the margin that opens on the sutural furrow a series of papillæ that form a continuation with the papillæ above-noted on the sides of the lateral plates, from which they differ only in being not flattened, nor are they at the same time so regular and closely placed. The adambulacral plate presents a wedge-shaped projection into the furrow, and carries five or six papillæ, three only of which usually stand on the margin of the ambulacral furrow, the remaining two or three (which are generally much smaller) being situated on the aboral margin opening on the sutural furrow of the interbrachial area; not unfrequently, however, one of them is as large as the ambulacral spinelets, and is placed somewhat inward upon the plate, away from the sutural fringe and behind the ambulacral series. Towards the extremity of

the ray the adambulaeral plates stand next to the ventro-marginal plates, and are not separated from them by the trapezoid imbrieating seales above described.

Each pair of mouth-plates forms an ovoid mass, the inner or apposed margins of the plates being elevated into a prominent keel. The innermost pair of mouth-papillæ are very large and thick, and taper to a point—the remainder, from 7 to 9 in number, being eonsiderably smaller and arranged round the free margin of the plate. Along, or near to, the median keel of the mouth-plate are 3–5 coarse spinelets, the innermost being large and thick, and are mueh less pointed than the marginal series. The madreporiform body is frequently not more than its own diameter distant from the margin, and is generally oval in outline and eovered with elongate striæ running in the direetion of the major diameter.

The entire body and all its appendages are eovered with an investing leathery skin.

Size.—Ordinary speeimens are about 30–40 millims. in diameter, the largest reeorded by Sars, from Tromsö, beiug 65 millims.

Colour.—The eolour is reeorded as brown-red; specimens preserved in spirit are either black, greenish, or various shades of drab.

Habitat.—*Ctenodiscus corniculatus* is found in mud or soft elay bottoms at very various depths, being dredged by Sars, at Finmark, in 40–200 fathoms depth; and further south, at Christiansund, in 40–80 fms. It has also been taken in 25 fms. at Arksut, by Barrett; and at Igaliko, in 60 fms., by Insp. Möller (*Lütken*).

Premature Form.—The young form of this speeies was deseribed by Müller and Troschel under the name of *Ct. pgmæus.* Small individuals, of about half an inch in diameter, are eharaeterized by the flatter test, the comparatively greater prominenee of the latero-dorsal spinelets, and the three large, conspicuously-developed spinelets whieh are present on the terminal plate of the ray. The upper margin of this plate, whieh lies towards the centre of the disk, is fringed with a series of papillæ similar to those on the sides of the lateral plates; and these papillæ, as well as the spinelets, appear to be subjeet to a greater or lesser degree of obliteration (or resorption) during the progress of the growth of the Starfish; in fact in old speeimens the spinelets beeome redueed to mere tubercles.

Aeeording to Lütken, the apieal prominenee in the centre of the disk is more prominent and eharaeteristically developed in young forms; but in the speeimens whieh we have examined (from Novaya Zemlya) it would appear to be quite the reverse, for we have been unable to deteet any differenee, except a proportional diminution in size, from the eondition presented by the mature animal. The adambulaeral plates in these speeimens bear their papillæ or "ambulacral spines" on the furrow-margin, with one large one plaeed thumb-like behind them on the aboral side.

At the extremity of the ray there are only two of the ambulaeral spinelets; and the thumb-like spinelet is larger than either of them, and is persistently present on every plate. The mouth-plates are small and simple, having only three or four mouth-papillæ on the margin of each plate, and two only on the median ridge (or at most three), the innermost of these being very large and prominent, and standing perpen-

dicular to the plane of the plate, midway between the extremities. When the young Starfish is examined under the microscope from above, it will be seen that in the lateral sutural furrows, which open on the dorsal surface, there are, in addition to the marginal fringe of compressed spinelets, an inner series of fine, pointed, cilia-like spinelets, at least at the upper portion.

In the early stages of this species, the lower or ventral series of lateral plates lies much more upon the actinal or ventral surface of the Starfish than it generally does in the fully grown form. In the examples above mentioned the row of single or true lateral spinelets, borne by the ventro-lateral plates, stands almost at the angle formed by the vertical side of the test and the actinal surface, the plates themselves arching sharply under, onto the actinal surface. The spinelets also seem to occupy a position relatively nearer to the centre of the plate than at a later stage. In large specimens no portion of the lateral plates curve onto the ventral area, and the spinelets are situated much nearer to the upper extremity of their respective plates.

Variations.—Dr. Lütken records examples from a station off Norway, which probably lies near the southern limit of the area of distribution, that differ strikingly from the normal short-armed form by their longer and more pointed rays, whereby the contour approaches that of *Archaster Parelii*; but in other respects no differences were noticed. We have observed a similar variation in the radial proportions amongst a series of specimens from Barents Sea, but not developed to such a marked degree as in those examined by our learned contemporary. The relative proportions of the greater to the lesser radius in two specimens are respectively 17 millims. to 9·75 millims. in the one, and 17 millims. to 7 millims. in the other; two smaller examples measured similarly 10 millims. to 6 millims., and 10 millims. to 5 millims.—the difference in character presented by the wide and gentle curve of the arm-angle of the one in comparison to the more acute and angular outline of the other being much more striking to the eye than the figures which indicate the actual proportions would seem to imply. From the occurrence of both these forms together, as well as the identity of their general structure, it is, perhaps, not improbable that we have here nothing more than a sexual character.

Upon the whole, this species would seem to be remarkably constant. After a careful study, however, of specimens from Greenland, Novaya Zemlya, and North America, we are inclined to believe that a certain amount of variation does occur (probably of locational permanence) in the features of the ventro-lateral plates and of the ambulacral spines, after the manner indicated whilst treating of the phases of growth; and although this would seem rather like a confusion of the stages characteristic of growth with the features presented by circumstantial variation, the evidence has been such as to lead to the inference that certain characters of early growth-phases are, in some localities, retained until a much later period of growth,—perhaps even becoming a permanency through life—a state of things which is perfectly explicable on the not improbable assumption that the exigencies of arctic existence have acted in

retarding the progress of growth-characters and in the maintenance of the youthful or more simple form. The spinulation of the paxillæ is similarly subject to variation.

Distribution.

a. *Greenland*: Hare Island, Waigat Strait, lat. 70° 30′ N., 175 fms. (‘ *Valorous*’ *Exped.*).

b. *North of American Continent*: Melville Island, about lat. 74° 47′ N., long. 110° 48′ W. (*Parry's Exped.*); Assistance Bay, 7–15 fms. (*Penny's Exped.*); Newfoundland (*Sars*); Bay of Fundy, 50–60 fms. (*Stimpson*); Maine.

c. *North of European Continent*: Spitzbergen (*Lütken*); Barents Sea, lat. 76° 58′ N., long. 45° 40′ E., 110 fms. (‘ *Willem Barents*’ *Exped.*), the most northern locality on record; Finmark; Scandinavian coast.

Description of the Illustrations of this Species on Plate III.

Fig. 17. Abactinal aspect of the animal: natural size.
18. Actinal aspect of the same specimen: natural size.
19. Portion near the middle of a ray, actinal aspect: magnified.
20. Portion near the middle of a ray, abactinal aspect: magnified.

OPHIUROIDEA.

The Ophiuroidea collected in Smith's Sound, in Discovery Bay, near Cape Frazer, Hayes Point, and Franklin-Pierce Bay, and in some other localities in those high latitudes, were numerous in individuals, but the number of genera and species was restricted. Some specimens were collected in Baffin's Bay, but so far to the south (lat. 65° N.) that their consideration hardly comes within the scope of this monograph; they will, however, be noticed briefly.

All the Ophiuroidea of Smith's Sound and to the north belong, with one exception, to well-known genera and species; and it is interesting that a comparatively new genus should be represented by a well-marked species and large individuals.

List of the Species.

1. *Ophiopleura arctica*, Duncan. Discovery Bay, 25 fathoms.
2. *Ophioglypha Sarsii*, Lütken. Floeberg Beach, 10 fathoms; Discovery Bay, 25 fathoms; Hayes Point, 35 fathoms.
3. *Ophioglypha robusta*, Ayres. Discovery Bay, 25 fathoms; Richardson Bay, 70 fathoms; Hayes Point, 35 fathoms; Franklin-Pierce Bay, 15 fathoms.
4. *Ophiocten sericeum*, Forbes. The same, with the omission of Richardson Bay.
5. *Amphiura Holbölli*, Lütken. Franklin-Pierce Bay, 15 fathoms.
6. *Ophiacantha spinulosa*, Müller & Troschel. Discovery Bay, 25 fathoms; Cape Frazer, 80 fathoms; Franklin-Pierce Bay, 15 fathoms.
7. *Astrophyton Agassizii*, Stimpson. Latitude 78° 19′ N.; depth 600 fathoms.

Species found to the South.

8. *Ophioglypha Stuwitzii*, Lütken. Latitude 65° N., 26 miles off the coast of Greenland; depth 60 fathoms.
9. *Ophiopholis bellis*, Linck. In the same place.

The temperature of the water whence the six species from the higher latitudes were dredged was 29°·5 Fahr.

Genus OPHIOPLEURA, *Danielssen & Koren.*

Lütkenia, Duncan.

This genus was determined by MM. Danielssen and Koren in 1867, and the diagnosis was published in the 'Nyt Magazin for Naturvidenskaberne,' Christiania. The specimens were obtained in the Norske Nordhavsexpedition, whose Echinodermata were placed in the hands of those distinguished naturalists. Before this description came to hand, the genus *Lütkenia* had been described, in order to include a species

founded on two fine specimens, in August 1878 *. But it became evident, on the reception of Danielssen and Koren's communication, that they had forestalled the genus *Lütkenia*, which is, of course, a useless synonym of *Ophiopleura*.

The following is the generic diagnosis of *Ophiopleura* :—

"The skin of the disk is hard, naked, smooth, and covers a rich plating of scales. The arms are in like manner overlaid with a smooth, thin skin, which extends up on the side spines and lets the arm-plates appear. The back of the disk has ten elevated ribs. Mouth-papillæ occupy both sides of the mouth-slits, and are flat, with rounded, smooth margins. The teeth form irregular rows, are compressed, and have a broad basis. Foot-papillæ. Two genital clefts in each interbrachial space."

The diagnosis published in the 'Annals and Magazine of Natural History,' August 1878, page 188, under the title of *Lütkenia*, is as follows :—

"Disk notched, covered with very small scales. Radial shields small, widely separate. Mouth-papillæ numerous. Tooth-papillæ. Teeth resembling tooth-papillæ in double series, with accessory knobs. Generative slits small, midway between mouth-shields and margin. Accessory scales to tentacular openings; tentacle-scales numerous; on mid arm two. Spines small, distant, irregular. Lower arm-plates very broad and short within the disk, and small and triangular without. Side arm-plates meeting below throughout, but not above. Upper arm-plates broad and keeled near the disk."

Ophiopleura arctica, *Duncan* †. Plate IV, Figs. 1–2*c*.

The disk is large, subcircular in outline, tumid above and at the sides, flat below, and is notched over the arms ($1\frac{4}{10}$ inch in diameter).

The arms are twice and a half as long as the disk is broad, come well within it, are very broad within the disk, and considerably so until the second third of their length. They are flat beneath, convex and almost keeled above near the disk, and less so distally, tall at the sides, and generally triangular in outline. The arm-spines are very small and few in number. The colour is white with a little brown.

The upper surface of the disk and the interbrachial spaces, to the aboral edge of the mouth-shields, and except the naked radial shields, have a stout flaccid derm, covered with excessively minute scales. The radial shields are small, pear-shaped, narrow, and angular within, where they slightly overlap, and broad and curved without, with a free edge there; they are very distant, and bound the incision for the arm on either side ($\frac{2}{10}$ inch long). Many small scales, some elongate and others extremely small and oval, are situated between the radial shields and the arm. There are no radial scales with spines; and the generative plates are hidden.

The mouth-shields are small ($\frac{3}{20}$ inch long), about as broad as long, somewhat pentagonal, broadest without, angular within, the aboral edge being nearly straight. The

* 'Annals & Magazine of Natural History,' ser. 5, vol. ii. p. 188. P. Martin Duncan on "*Lütkenia*."

† Ibid. pp. 188 & 266.

sides of the shields are rather straight and are at right angles to the aboral margin for some space, and then they slope inwards to the oral point. An accessory plate exists, in some, between the oral angle of the mouth-shield and the side mouth-shields. The madreporic plate is cribriform.

The side mouth-shields are rather large, do not unite closely within, are long and rectangular, being widest at the side angle of the mouth-shield, where they are more or less pointed, curved, and rounded off.

The generative slits are short and linear; the edges are close together, and have on them small, flat, rounded spinules, sixteen or more on each; they are distant from the mouth-shields and from the margin of the disk; and a series of fine scales passes outwards from their distal end, by the side of the arm, to the margin. Other minute scales are in a patch on the oral side of the slits.

The jaws are rather long, stout, tumid and bossed, and form rather a sharp angle; and the lower edge of the jaw-plate is broad and stout; the angular spaces are wide and large; and the tentacles are very well developed.

There are mouth-papillæ and tooth-papillæ; and the teeth are in a double vertical series with some accessory knobs, so that they resemble large tooth-papillæ.

The mouth-papillæ are numerous, fourteen or fifteen to each angle, small, much joined together at their bases, irregular in size, shape, and number, short, and never very broad. At the apex of the angle, within the distinct jaw-plate, there are three principal, and one or more smaller, lowest tooth-papillæ. No satisfactory distinction, except that of position, can be made between these tooth-papillæ and mouth-papillæ. Above the three or more lowest tooth-papillæ, the others are in a crowded vertical series. They are most numerous and small on either side; and there are six or seven pairs of large, long, pointed and irregular-shaped ones in the midst, and reaching up the jaw-plate to its upper end, occupying the position of the teeth. The side of the jaws, close to the jaw-plate, is occasionally covered with small and close papillæ; and there is a small accessory papilla close to and at the side of the uppermost large ones. The upper part of the jaw beneath the stomach is stout and tumid, and the jaw-plate is large and well developed.

There are two rounded knobs on the side of the jaw, above the attachment of the mouth-papillæ, which are in relation with the upper tentacle; and the lower tentacle of the angle has five or six short unequal-sized tentacle-scales, forming, with several accessory scales, an obliquely placed curved wedge-shaped mass within the first lower arm-plate and on either side of its oral margin.

The lower arm-plates, there being six or seven within the disk, are mostly very broad and very short; further out they are small and triangular, with an aboral projection. They form but a small portion of the lower surface of the arm. The side arm-plates meet below, from the first to the last, giving a broad and comparatively flat under surface.

The first lower arm-plate is unlike the others in shape, and it is elliptical in outline and much broader than long; the second, longer and very much broader than the first, is somewhat rectangular; its sides are slightly incurved; and there is a

central angular process on the distal and proximal edges, from which there is a reentering curve on either side to the lateral angles of the sides of the plate.

The third lower arm-plate is very broad, extending across the arm; it is short, the relation of length to breadth being one to three; the sides are incurved for the tentacle, and are slightly convex towards their distal angle. There is an angular process or cusp on the broad oral margin, and a smaller one on the aboral; and there is a reentering curve on both sides of the processes, giving a very elegant outline. The fourth lower arm-plate is as broad as the third; but it is shorter, and the proximal angular process is more decided than that on the distal edge. The next plate has the general shape, but is shorter, and the proximal angle is more pronounced. From this plate to the end of the arm the others narrow more and more, become angular at the sides and more or less triangular as a whole, and are broader without than within. There is a projection in the median line on the aboral margin, and a reentering curve on either side to the lateral angles; and the proximal angular process has faintly reentering curves on either side of it. Far out and towards the tip of the arm, the lower plates become more quadrangular or diamond-shaped; they are small, broader than long; and there is an angular process without and within. At the tip the minute lower arm-plates have the distal edge curved, and they are angular orally.

The first lower arm-plate is separated from the side mouth-shields by several scales or plates, which are continuous with the base of the tentacle-scales already mentioned as being within and at the sides of the plate.

The second lower arm-plate has two or three small tentacle-scales on it. In some arms they are fused into one; or there may be several minute accessory scales present.

The third plate has the same number and accessory arrangement; and they are seen, more or less modified, in the fourth and fifth. The other lower arm-plates have no tentacle-scales.

The side arm-plates form much of the lower surface of the arms, and also the greater part of the sides in mid arm and towards the tip. All unite with their fellows along the median line below; and all are convex from side to side. The first, just touching its fellow in the median line, is oval in outline, broader than long; it supports five, short, close tentacle-scales on a curved base; and the tentacular opening is large and circular, having a rim of membrane. The second is broader than the first, touches its fellow, and has four tentacle-scales, and sometimes a fifth or a small accessory one.

The third side arm-plate, still broader than long, and not much longer than the second, touches its fellow by a longitudinal short and straight line. The margin without is curved boldly, and within very slightly. Like the others it is flat below; and it has three tentacle-scales, the outer one being subspiniform. The fourth, still broader, is not longer; and its outer end is large and supports three tentacle-scales, one of which is sometimes wanting. The fifth plate the broadest, is short, and is narrow towards the median line, where it has two small tentacle-scales close together; and there is a spinule external to them, and sometimes a second.

Between the tentacle-scales of these first five or six tentacles and the generative slit, there are occasionally one or two spinules.

Towards the mid arm, the side arm-plates are tumid at the sides, nearly flat below, broader than long, and shortest where they are joined longitudinally. They have a sharp bend to reach the side of the arm, and terminate above in an angular edge by joining the outer edges of two upper arm-plates. Their distal margin, at the side of the arm, is thick, and supports two very small, distant, irregular, sharp, short spines and two tentacle-scales, the inner of which is small and scale-like; and the outer is usually, but not invariably, a minute spine longer than the scale and the other spines. Sometimes the two tentacle-scales are equal; and further out the largest spine becomes independent of the tentacle. There are often no spines, while some plates have several very minute ones. All are very ill-developed and small.

The side arm-plates form the bulk of the tip of the arm; but, although convex at the sides and swollen above, they do not separate the small and somewhat elongated hexagonal upper arm-plates there.

The upper arm-plates, within the notch in the disk, are four in number, and are broad, short, and curved to form a convex roof-like surface. Until far out on the arm, all are much broader than long, and have slanting straight sides and very faintly curved distal and proximal margins; the plates are convex and angular longitudinally, and they form the upper and much of the side arm. A little beyond the mid arm, the upper arm-plates are smaller, not much broader than long, broadest without, where they are curved; and further out they are longer than broad, narrow proximally, with sides reenteringly curved and the distal margin boldly curved without. Towards the tip the elongated hexagonal form is assumed, the distal edge, however, being curved irregularly.

Remarks.—Two specimens of this fine Ophiuroid were collected by Mr. Hart: one is in spirit, and the other is dry, in the British Museum; and they both have the same anatomical details.

The minutely scaled disk, the widely separated radial shields and their free aboral edge, the position and ornamentation of the generative slit, the presence of mouth- and tooth-papillæ, the absence of true teeth in the ordinary sense, the papillose nature of the jaws, the accessory scales to the tentacular openings, the shape of the lower arm-plates, the numerous tentacle-scales and few spines on the side arm-plates, and the angular roof-shaped upper arm-plates, whilst they partly suggest Amphiuran and Ophioglyphan affinities as a whole, are very characteristic. The absence of spined generative and radial scales, and the presence of tooth-papillæ, separate the new forms from *Ophioglypha*; and the nature of the dental apparatus and tentacle-scales prevents their being placed in any hitherto known arctic genus, except *Ophiopleura*.

The specimens were dredged in Discovery Bay at a depth of 25 fathoms, the temperature being 29°·5. The species has since been found in high latitudes on the eastern side of Greenland.

Ophiopleura borealis, Danielssen & Koren, was not found very far north, and only in latitude 63° 5′ N., and to the east of Greenland; but the specimens were from considerable depths, 510 to 570 fathoms, and the bottom temperature was above

freezing-point, 1°·3 Centigrade. It is distinguished from *Ophiopleura arctica* by the presence of 10 very definite rib-like elevations of the upper surface of the disk, and by its large disk-scaling, and general greater robustness and dimensions of the whole body. The species *Ophiopleura arctica* has a more pentagonal outline; the upper arm-plates are more convex and medianly more pointed; and in shape the second and third lower arm-plates differ entirely from those of *Ophiopleura borealis*. The other lower arm-plates of this last species have the breadth, but the few within the disk have not the aboral point of the arctic form. The jaws differ in shape: the accessory pieces are not seen in *Ophiopleura borealis*. And its tentacle-scales are differently arranged and are more numerous in mid arm than in *Ophiopleura arctica*. The arctic forms have round tentacle-spaces, and the others have them elongate, at the root of the arms. The mass of tentacle-scales and accessory pieces at their base, in relation to the tentacle at the side of the first lower arm-plate, are very strongly marked in the form from Smith's Sound, but not so in that described from the sea to the east of Greenland. Both are very fine forms and large; and the slight increase of dimensions in the boreal type is not sufficient to explain the structural differences.

In estimating the importance of the remarkable condition of the true teeth in *Ophiopleura arctica* it is necessary to remember the great variations of the teeth of such a form as *Ophioglypha texturata*, Lamarck, sp. Hardly any specimens of this species can be found with entire teeth, so constantly are they divided and conical. The same remark holds good for *Ophioglypha Sarsii*, Lütken, sp.

Description of the Illustrations of this Species on Plate IV.

Fig. 1. The upper part of the disk and arms: natural size.
2. The under surface of the disk: magnified.
2 *a*. The teeth, on the jaw-plate, oblique view: magnified.
2 *b*. The teeth from above: magnified.
2 *c*. The teeth approaching: magnified.

Genus OPHIOGLYPHA, *Lyman*.

Ophioglypha, Lyman, Proc. Bost. Soc. N.H. vii. 1860.
Ophiura, Forbes.

Disk covered with unequal, crowded, naked, more or less distorted scales, some of which are swollen. Radial shields naked and swollen. Teeth: no tooth-papillæ. Mouth-papillæ long within, but small and short near the outer edge of the mouth-tentacles. Arm-spines few, arranged along the outer edge of the side arm-plates. Tentacle-scales numerous; the innermost pair of tentacle-pores shaped like slits, surrounded by numerous scales, and opening diagonally into the mouth-slits. Side arm-plates meeting nearly or quite below, but not above. A notch edged with papillæ over the arm in the disk. The genital slits starting from the mouth-shields.

Ophioglypha Sarsii, *Lütken*, sp. Plate IV, Figs. 3, 4.

Ophioglypha Sarsii, Lütken, Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn, November 1854.

An *Ophioglypha* with mouth-shields shield-shaped, longer than broad; length less than, or only equal to, their distance from the margin of the disk. Papillæ of the disk-incision about fifteen and rather broad. Under arm-plates widely separate, of a very broad, short triangle-shape. Two tentacle-scales. No infrabrachial indentations. Spines rather long, equal in length to the side arm-plates.

This is the most northerly Echinoderm brought home by the Expedition, a fine specimen, with a disk-diameter of 26 millims., having been taken by Capt. Feilden at the winter-quarters of H.M.S. 'Alert,' in N. lat. 82° 27′, in 10 fathoms. Other examples of this species were obtained at Discovery Bay in 25 fathoms, and among them one which is provided with remarkably long arm-spines, being in relative proportion fully twice the length of the spines generally occurring in *Ophioglypha Sarsii*. In this individual the three spines of the sixth joint measure respectively 2·45 millims., 2·25 millims., 1·4 millim., the under arm-plate being 0·7 millim. long, the arm-joint 1 millim., and the disk-diameter 15 millims. The remaining features of the specimen agree too closely with the characters of *Ophioglypha Sarsii* (Lütken, sp.), in our opinion, to warrant its removal from that species, even as a provisional variety. Specimens were also found off Hayes Point.

In some cases great irregularity is exhibited in the mouth-papillæ, one abnormal example being particularly worthy of notice. In the *Ophioglyphæ* the innermost mouth-papilla generally stands immediately under the teeth, and might be easily mistaken for a tooth, being, in fact, affixed to the tooth-plate and not to the lateral plates. In *O. Sarsii*, as well as in other members of the genus, two additional papillæ are generally associated with it, one on either hand, and are in like manner borne by the ossicle upon which the teeth are placed.

In consequence of this arrangement it has long seemed probable to us that these subdental papillæ should be regarded as tooth-papillæ (of which they are in truth the homologues) rather than as mouth-papillæ so-called, along with which they are commonly counted. One of the specimens taken in Discovery Bay throws considerable light upon this question.

In this individual the dental armature consists of four teeth regularly superposed, following upon which, and occupying the same breadth as a tooth, are three ossicles which fit to one another, wedgewise, with sloping sides. Then come two which fit together and correspond in their shape with the irregularities of the upper and under tier, which latter consists of from three to five compact, close-fitting papillæ; and these again are succeeded by three or four (in some rays five) moderately long, round-tipped, smaller papillæ, the whole forming a compact mass suggestive, in the highest degree, of ordinary tooth-papillæ, such as occur, for instance, in *Ophiothrix*; and yet in every detail, even to measurements, the specimen conforms to the diagnosis of *Ophioglypha Sarsii*. This individual has a disk-diameter of 22 millimetres.

Bearing in mind the tendency towards vertical reduplication of the mouth-papillæ in some genera, this cannot fail to be regarded as suggestive of the manner in

which primitive tooth-papillæ may have been developed; nor is such an assumption by any means extravagant when the great irregularity of these parts amongst Arctic forms is taken into consideration.

The specimen of *Ophioglypha Sarsii*, the teeth of which have been alluded to as being abnormal, is dry and of a dirty white colour. The disk has a pentagonal outline above, but is circular below; the notches for the arms in the upper part of the disk are distinct; and the scaling is small. There is a small circular scale centrally; and the radial shields are embedded, as it were, except at their outer extremity. Several scales separate the radial shields, some being larger than the others. The radial shields are separated aborally, by a linear groove, from distinct radial scales. These bear the majority of the flat, broad, closely-set spinules, which are continued on the interbrachial space below, along the generative slit, and finally touch the sides of the mouth-shield. A corresponding series of much smaller, adpressed and blunt spinules is on the side arms close to the others; and it can be traced, as a ragged dentate border, to the generative slit, close to the arm on the under surface of the disk. Three or four small upper arm-plates exist before the full-sized fifth is seen; and they are more or less within the notch; and their aboral edges are very faintly incised. Below, the mouth-shields have the usual shape of those of the species, and the side mouth-shields are small, and their outer and aboral part is in contact with the generative slit. About six close, short, blunt scales are on each, and are opposed to a smaller number of slightly larger tentacle-scales on the arm; and the tentacular opening (the 1st visible but the 2nd really) is long. The jaws are very short, stout, and lumpy inferiorly; and the jaw-plate is small. The mouth-papillæ, usually so symmetrical, are placed obliquely, are irregular; and the usual central one is replaced by from four to six smaller ones, which have been noticed before. The underpart of the side arm-plates near the disk somewhat resembles that of *Ophioglypha lacertosa*, Forbes, sp., being almost perforated where the oral angle of the under arm-plate nearly or quite touches the aboral edge of its predecessor. Union of the side arm-plates below, occurs at about the sixth or seventh. The three arm-spines are small, irregular in shape, are adpressed, rounded, and rather flat; sometimes a fourth is seen; and all are slightly constricted above their origin. Two tentacle-scales exist to the end of the arm; but in some joints there are three, or even four, small scales. In mid arm the tentacle-scales are on the side arm-plates only; one is short, broad, flat, and narrowed at its origin, and is internal to the other. Each either resembles a small conico-cylindrical spine, or is more like the first. In the neighbourhood of the disk the narrow peduncled and broad, short, blunted tentacle-scales, normally two on the side arm-plate over the tentacular opening, have a third, placed flat against the under arm-plate, from which it springs. Nearer the oral opening, the number of tentacular processes increases as usual. Where only one tentacle-spine exists, it is broad, and appears to be double with a common base.

Description of the Illustrations of this Species on Plate IV.

Fig. 3. *Ophioglypha Sarsii*, Lütken, the top: natural size.
4. *Ophioglypha Sarsii*, Lütken, the underpart of the disk.

OPHIOGLYPHA ROBUSTA, *Ayres*, sp. Plate IV, Figs. 5–7.

Ophiolepis robusta, Ayres, Proc. Bost. Soc. N. H. iv. 1851.
Ophiura squamosa, Lütken, Vid. Meddel., Nov. 1854.

An *Ophioglypha* with arms very finely tapering, and disk with regularly arranged scales of nearly equal size. Mouth-shields ovate shield-shaped; length less than, or at most only equal to, their breadth; length much less than the distance from the margin of the disk. Papillæ of the disk-incision very short and stout, often grouped. Under arm-plates broadly heart-shaped; one tentacle-scale.

This species was obtained at various stations, as indicated in the list of localities; and though neither the abundance nor the size of the specimens was remarkable, several good series were collected. The characters which have been regarded as "specific" are remarkably constant; and no essential difference can be traced between these Arctic forms and specimens taken from the coast of Maine, U. S., with which they have been compared, excepting that in the northern Ophiurans the arm-spines are longer and somewhat more delicate, and that the outer margin of the under arm-plates is more arched, and the reentering angle is far less developed, being even altogether untraceable in certain specimens. In some large examples the upper arm-plates are very markedly hexagonal. Although this deviation is very constant, the foundation of a "variety" on the strength of such characters alone, is hardly justifiable.

The arm-spines are moderately stout and tapering, the upper one being flattened and much larger than the others.

In most of the specimens under present consideration the under arm-plates are well separated from one another by the side arm-plates, and do not overlap, although in one individual from Discovery Bay the first ten impinge distinctly, in consequence of their side arm-plates not meeting. This feature at the basal portion of the arm has been noted by Dr. Lütken as occurring in large specimens from Greenland, whilst he remarks at the same time that in none of the Danish examples examined by him do the under arm-plates touch.

Coll. Feilden.—Discovery Bay, 25 fms., hard bottom; Richardson Bay, 70 fms.; Hayes Point, 35 fms., bottom temperature 29°·5, and also at 25 fms.; Franklin-Pierce Bay, 15 fms., bottom temperature 25°·5.

Coll. Hart.—"Winter quarters," Discovery Bay; Franklin-Pierce Bay, 13–15 fms., bottom stony.

The largest specimen was taken by Capt. Feilden in Franklin-Pierce Bay, the diameter of the disk (dried) being 10 millimetres.

The scaling of the upper part of the disk is very variable in its pattern, relative size, and colour. In one specimen the usual smaller scaling is in the centre, and the larger around; but the central scale is almost circular in outline, and is surrounded by smaller ones, some of which are triangular, with the apex broadly rounded and the intermediate one rhombic. This produces a curious rosette, eminently crinoidal in its configuration, but flat. The ornamentation of grains of calcareous matter on these scales is very beautiful; it radiates in numbers of separate and close lines of granules from the centre of the central scale to the outside of the bluntly triangular scales; and

the rhombic scales and the others around them, which are not very definite in shape, have their ornamentation radiating from their own centres.

In another specimen the scaling is perfectly irregular, no sign of a rosette appears, and the large radial shields are separated by several small scales in some radii and not at all in others, when one large overlapping scale is placed between, or rather overlaps their oral and diverging median line. In other specimens where there is a rosette the oral separation of the radial shields is by three large plates, one being flanked by others, or by two plates, one large and one small, the latter being aboral to the other. The ornamentation is not so much by grains as by cells which are not yet opaque with carbonate of lime. The radial shields are convex, large, and are broadly convex where more or less free aborally; they are separated aborally by small upper arm-plates, in some instances two, and in others three in number. The shields, thus separated aborally, and, as has been mentioned, orally, are united in some instances along a very short line. With regard to the upper arm-plates within the notch, the first is often more or less triangular in shape, with rounded edges, and the apex is oral; and when this shape prevails, this plate is usually larger than the second, which is broad, short, and sometimes notched distally. The third is larger, and shaped more or less like the second.

The spinules, which are stout, distinct, and more or less grouped in two rows, are not often more than six or eight in number. They are beyond the radial shields, and appear to be on the derm between them and the upper arm-plates. It is evident that in some specimens there is a spine, or even two (but not in all radii of one specimen), on either side of the first and second arm-plates, and even on the third. This distribution of a few well-developed, short, stout, blunt spines is very characteristic. In some specimens, and in the largest, the first upper arm-plate is in two pieces.

The coloration of the upper part of the disk varies from a perfect white to a spotted state, with indefinite blue, black, and white, and brown and white. Blotches appear on the centres of the radial shields and larger plates, so that the whole assumes a maculated appearance. The slate-blue colour, very light in its intensity, may prevail so much on the disk that the white parts come out very decidedly; and usually that is the colour of the third row of the rosette, of the scales external to the radial shields, and of some scales in the interbrachial spaces near the edge.

The upper arm is banded in some specimens with the disk-colour and white; and usually the colour is lost towards the termination of the arms.

The upper arm-plates are much more convex in their distal curve in some specimens than in others; but in all they are much broader than long near the disk, and in mid-arm take on the kite-shape with the angle oral and the convex curve distal. Gradually they become longer than broad; and towards the end of the arms the side arm-plates meet above.

There is some variation in the shape and size of the mouth-shields; but their acute oral angle and broad aboral part are invariable. The side mouth-shields are small, narrow, much curved, and just reach to the end of the generative slit. Owing to the angular nature of the proximal part of the mouth-shields, the side mouth-shields, with

their very distinct oral reentering curve, produce as a series a beautiful festooning, the well-developed front lower arm-plate entering into the circle; for the side mouth-shields come up close to its flanks.

The jaws are small, short, narrow, and gibbous inferiorly, and are fringed with mouth-papillæ, one of which, or the homologue of a tooth-papilla, is large and solitary. This is larger than the others, is often spear-headed; and there are usually three smaller ones on either side of the jaws. As a rule, all these mouth-papillæ vary much in size and shape, and project obliquely downwards. The true teeth are angular and broadly spear-headed in outline; and they are in a single series of at least five.

The first lower arm-plate is either unlike the others in shape and is perfectly or irregularly elliptical, being broader than long from the oral to the aboral edge, or it is heart-shaped and broadest distally and truncated orally. The second and lower arm-plates are triangular, broad distally, where there is a bold curve, and angular orally, the sides sloping, with scarcely any reentering curve; the length and breadth are about equal. The next and following plates retain their oral angle and broad distal curve, which is sometimes notched in the median line; but the sides near the distal corners are at first parallel and form a space for the tentacle, and then they slope in with more or less of a reentering curve to the angle. Far out they become smaller and smaller and fan-shaped, with reentering curves on the sides, and often have a slight notch.

The side arm-plates unite under the arm, and become longer and longer until they occupy most of the under surface. After the fourth or fifth tentacle-opening there is one small scale, or, rather, conico-cylindrical and blunt small spine. The first visible tentacle-opening has four, and rarely five, scales on either side of it; the next has some (three) rudimentary scales on the lower arm-plate, and one larger and flat scale on the side arm-plate; under the next lower arm-plate there is often a rudimentary scale, besides the fully developed one on the side arm-plate.

The arm-spines, three in number on mid arm, are slender; and the upper one is the longest. There is a row of blunt and distinct small spinules (much smaller than those in relation to the radial shields) on one side of the generative slit; but they are large in relation to those of other species.

Lyman, after noticing that *Ophioglypha robusta* differs from the other species of the genus in its short, broad mouth-shields and finely tapering arms, states that it has been found even in the high latitude of Wellington Channel. He quotes A. E. Verrill, who states that its range generally is from low-water mark to 18 fathoms. Lyman's description of the typical specimen and of some varieties may be read with great advantage.

Description of the Illustrations of this Species on Plate IV.

Fig. 5. The species, natural size, from above.
6. The under surface of the disk: magnified.
7. The upper surface of the disk: magnified.

Genus OPHIOCTEN, *Lütken.*

Ophiocten, Lütken, Vid. Meddel. 1854.

Disk very flat, with margin forming a sharp angle; covered with imbricating scales and a superficial squamo-granular layer, through which only portions of the radial shields and primary plates are visible. No disk-incisions, the disk forming a little arch over the base of the arms. A row of papillæ edges the genital slit, and passes over the arm along the disk-margin, continuous with the series from the other side. The mouth-shields are scutiform, and are prolonged into the interbrachial space. The first group of tentacle-scales pass inwards, close to the angle of the jaws. Three arm-spines, arranged along the outer edge of the side arm-plate, the two upper spines being much the largest.

Ophiocten sericeum, *Forbes*, sp. Plate IV, Figs. 8–10, 14.

Ophiocten Krœyeri, Lütken, Vid. Meddel. 1854, p. 8.
Ophiura sericea, Forbes, Sutherland's Journ. Voyage Baffin's Bay, Appendix.

A typical specimen should have the outline of the disk, seen from above, perfectly circular, without arm-notches and without straight lines to the margin of the interradial areas. The disk is slightly tumid above; and the sharp margin merges into a more largely scaled and flatter under-disk. Disk tessellated with circular plates, one in the centre, five around at some distance, and a few others, but all separate and ornamented with radiating lines of cells, all being surrounded and overlapped by a derm of minute circular scales cellular in aspect. The radial shields, which are wide apart, are larger than the other plates, narrowest aborally and broadest within; obliquely placed, their distal end being arched and free; and between them, under the derm, are some rudimentary upper arm-plates. There are distinct radial scales projecting beyond the radial shields; and on their distal edge from 5 to 7 spinules with narrow bases, swollen cylindro-conical trunks, and rather angular and sharp terminations are visible. These are in a row; and there are others in some instances projecting from the cells of the derm between the radial shields, and, deeper still, from the rudimentary upper arm-plates.

The upper arm-plates, broad, short, and convex near the disk, form much of the arm; and usually the first five or six large ones are covered with a row of smaller spinules than those on the edge of the disk, which project along the line of, and close to, the arm, extending, in some, along the whole distal curve. After the fourth they diminish in number; and one or two only are seen on the six arm-plates further out.

The upper arm-plates increase gradually in length, and only diminish in breadth far out, and at last become more or less triangular in outline, whilst quite at the top they are long, narrow, triangular, and separated by the side arm-plate. In some specimens there are no spinules on the upper arm-plates.

Beneath, the scaling is larger and overlapping in the interbrachial spaces, and is

often large near the mouth-shields; and the junction of the two kinds of scaling at the margin is sharp.

A row of spinules is often (but not always) seen along the generative slit, and is continuous with that seen above the arm.

The mouth-shields are distant from the edge, and are boldly curved and almost circular, except orally, where they are produced into an angle; and there are many variations of this shape. The side mouth-shields are small, swollen and enlarged where they impinge against the first side arm-plate; and they end between the first two tentacle-openings visible under the arm. They are united orally in some instances; but as a rule the union is not perfect; and each carries a broad short scale which protects the large first arm-tentacle, and which may be divided into two or even three parts. The jaws are often slightly separated in front of the side arm-plates; and they are swollen just within the large and often triangular-looking jaw-plate. There are four or five mouth-papillæ on each jaw-margin, the aboral being broad and short, and the others more or less spiniform or spear-headed. A large papilla is below the true teeth on each jaw-angle; and it and one on either side are to be seen on the jaw-plate.

The tentacular openings are very large; and the first under the arm opens, as it were, along the side of the jaw. The tentacle-scales are few, and like broad plates—there being not often more than two on the side arm-plate, and two or three on the side mouth-shield.

The special characters of *Ophiocten sericeum*, as given by Lyman, are:—"Arms three to four times the length of the diameter of the disk; two upper spines much the longest; papillæ of arm evenly continuous, 1–4 upper arm-plates bearing papillæ."

The main variation which we have noted in the Arctic specimens of this species consists in the greater length of the arm-spines as compared with those of more southern examples. In a specimen 9·2 millims. in disk-diameter the length of the upper arm-spine of the sixth joint was 1·85 millim. (in one case 2·3 millims.); in another, with a diameter of disk of 8·5 millims., the same spine was 1·8 millim. long, three arm-joints in this individual being exactly 2 millims. In addition to the above, variations occur in the contour of the mouth-shields; and in the larger examples considerable irregularity is also found in the number and position of the mouth-papillæ. Amongst this collection are several specimens having a very decidedly pentagonal form of disk. In our opinion none of the above variations can be regarded as of greater morphological significance than growth-phases, or, at most, than individual variations. The largest specimen obtained was 11 millims. in disk-diameter.

Numerous specimens were collected by both of the naturalists of the Arctic Expedition; and one set was collected by Capt. Feilden in Discovery Bay, 25 fms., hard bottom, Cape Frazer, 80 fms., and Hayes Point, 35 fms., bottom temperature 29°·5. The others were in Mr. Hart's collection, from Discovery Bay, 15–20 fms., muddy bottom, also at 11 fms.; Franklin-Pierce Bay, 13–15 fms.

Description of the Illustrations of this Species on Plate IV.

Fig. 8. The upper surface: slightly magnified.
9. The scaling of the upper part of the disk and part of the arm: magnified.
10. Part of the underpart of the disk: magnified.
14. Part of the disk-scaling: magnified.

Genus AMPHIURA, *Forbes.*

Amphiura, Forbes, Linn. Trans. vol. xix. 1842.

Disk small and delicate, covered with naked overlapping scales, and furnished with uncovered radial shields. Teeth: no tooth-papillæ; six (rarely eight) mouth-papillæ to each angle of the mouth. Arms slender, even, more or less flattened. Arm-spines short and regular along the sides of the arm-plates. Two genital slits.

Amphiura Holbœlli, *Lütken.* Plate IV, Figs. 15–17.

Amphiura Holbœlli, Lütken, Vid. Medd., Nov. 1854, p. 98.

The mouth-papillæ are six to each angle of the mouth (the two innermost stoutest and pointing to the centre of the mouth), and are oblong and running upwards towards the teeth. The innermost papilla is attached to the side mouth-shield; it is small, flat, with a curved cutting-edge, and is long and sharp like a canine tooth. Teeth four: two uppermost large, flat, longer than broad, squarish, rather thick, presenting a broad free surface. Mouth-shields rounded, truncated, and narrower without; and madreporic shield the largest, and with pores on its edge. Side mouth-shields large, broad, and triangular, with all their sides reenteringly curved, meeting within, and also their neighbours, between the first and second under arm-plates.

Only a single specimen of *Amphiura* was taken in high latitudes; and this, although it differs slightly from the type form in the relative measurements of certain points of detail, we have little hesitation in assigning to Dr. Lütken's species, the variations, in our opinion, not being of greater importance than such as we should regard as dependent on locality and conditions of life.

The solitary specimen was found in Franklin-Pierce Bay in 15 fathoms, the temperature being 29°·5 Fahr., and presents the following characters:—

An *Amphiura* with disk lobed; radial shields long and narrow; mouth-shields rounded; side mouth-shields large, subtriangular, with the sides reentering and angles rounded. Three pairs of mouth-papillæ, the middle ones placed higher than the others. Under arm-plates pentagonal. One tentacle-scale, rounded. Arm-spines three or four.

The arms are less broad, and take their origin in a more deeply reentering curve of the disk-margin; the radial shields are narrower; and the breadth of upper arm-plates, in proportion to their length, is less than in the type forms, as the following measurements will indicate:—Diameter of disk 8 millims.; radial shield, length 1·3 millim., breadth 0·35 millim.; sixth upper arm-plate, length 0·6 millim., breadth 0·9 millim. The spines are hollow cylinders, stout, blunt, and but slightly tapering; the upper spine on

each side-plate tapers most. The first fifteen arm-joints bear four spines, the succeeding joints three only.

An interesting feature connected with this specimen is worthy of record, and is one which does not appear to have been noted by previous observers. The central spines are more or less flattened throughout their whole length; and at the tip, compression has been carried to such a degree as to form a thin and somewhat expanded head—a peculiarity which is at once suggestive of a characteristic spine-appendage possessed by *A. filiformis*; and although, in the specimen under notice, this structural feature is by no means so fully developed as in that Ophiuran, it is still sufficiently marked to impress upon the mind the near relationship of the two species, and the community of their descent—an hypothesis which is also further strengthened by the association of both the forms in more southern waters.

Description of the Illustrations of this Species on Plate IV.

Fig. 15. Part of the underpart of the disk: magnified.
16. Radial shields: magnified.
17. Side view of the arm: magnified.

Genus OPHIACANTHA, *Müller & Troschel.*

Ophiacantha, Müller & Troschel, Syst. Ast. 1842.

Disk with little thorny spines. Radial shields covered. Teeth; mouth-papillæ; no tooth-papillæ. Spines numerous, slender, minutely thorny, arranged on the sides of the side arm-plate. Side arm-plates meeting nearly, or quite, above and below. Two genital slits, beginning outside the mouth-shields. (*Lyman*, op. cit.)

Ophiacantha spinulosa, *Müller & Troschel.* Plate IV, Figs. 11–13.

Ophiacantha spinulosa, Müller & Troschel, Syst. Ast. 1842, p. 107.

An *Ophiacantha* with disk covered with small round scales, each bearing a small short spinelet. Radial shields very obscure, sometimes quite covered. No disk-incision; and the dorsal membrane is prolonged over the base of the rays. Mouth-shields twice as broad as long, irregular ovate. Side mouth-shields long, narrow, arched, and meeting within. Under arm-plates heptagonal or sub-heptagonal; breadth equal to length. Dorsal arm-plates triangular. Side arm-plates meeting above and below. Spines 7 or 8, long, thin, and denticulate, placed on a keel.

A greater number of this Ophiuran were brought home by the British Arctic Expedition of 1875–6 than of any other Echinoderm. The specimens range in size from those having a disk-diameter of 15 millims. to the young form of only 3 millims., and consequently furnish a most instructive series.

The variations dependent on growth are very considerable, so much so that isolated specimens taken from different stages in the series might easily be regarded as affording the types of distinct species. Conclusive proof has been furnished by the material which we have had at our disposal that the *O. grœnlandica*, M. & T., and the *O. arctica*, M. & T., are untenable species, as Dr. Lütken has already pointed out; and, further,

that the characters which had hitherto been looked upon as of specific value, are not, as that eminent authority seems to infer, even variations such as can be regarded as dependent on distribution, but must be considered simply the phases incidental to age, together with ordinary individual variation.

Amongst the specimens procured by the naturalists of H.M.SS. 'Alert' and 'Discovery' there are many presenting features developed in a manner which might be regarded as "ultraspecific" when compared with the previously recognized modifications of this "form." In the present state of knowledge, however, it seems preferable to comprehend them under *O. spinulosa* of Müller and Troschel, rather than to burden further the nomenclature with novel designations.

The mouth-shields and the under arm-plates in this species are subject to very considerable changes and variations, both in contour and in their relative proportions of length to breadth. In large and adult specimens the number and arrangement of the mouth-papillæ is also irregular, and not only is there a frequent increase in number in the ordinal horizontal series, but there is also a great tendency towards reduplication of certain papillæ in the vertical axis of the Ophiuran. This seems to arise from the longitudinal cleavage of preexisting papillæ.

In young individuals the spinelets of the disk are proportionally long, five or six times their own diameter, and present all the appearances of ordinary embryonic spines. During the progress of growth, however, increase is made in thickness only; so that when maturity is attained, and the spinelets, along with the disk, are invested with the semitransparent leathery membrane of the body, the appearance is more that of short stumpy prominences than of actual spines—a deception which at first sight gives a totally different character to the Ophiuran.

Coll. Feilden: Discovery Bay, 25 fms., hard bottom; Cape Frazer, 80 fms.; Franklin-Pierce Bay, 15 fms., temperature 29°·5 Fahr. Coll. Hart: Franklin-Pierce Bay, 13–15 fms., bottom stony.

Description of the Illustrations of this Species on Plate IV.

Fig. 11. The upper surface: natural size.
12. Part of the under surface: magnified.
13. The spines on the disk: magnified.

ASTROPHYTIDÆ.

ASTROPHYTON AGASSIZII, *Stimpson*. Plate V, Figs. 1–6*a*.

1819. *Gorgonocephalus arcticus*, Leach, Ross's Voyage of Discovery in H.M.SS. 'Isabella' and 'Alexander, vol. ii. Append. No. iv. p. 178.
1841. *Euryale scutatum*, Gould (non Blainville), Invert. of Massachusetts, p. 345.
1853. *Astrophyton Agassizii*, Stimpson, Syn. Mar. Invert. Grand Manan, p. 12.
1865. *Astrophyton Agassizii*, Lyman, Ill. Cat. Mus. Comp. Zool. Harvard, i. p. 186.
1866. *Astrophyton Agassizii*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 344.
1866. *Astrophyton Agassizii*, Ljungman, Öfvers. K. Vet.-Akad. Fördhandl. 1866, p. 335.
1869. *Astrophyton Agassizii*, Lütken, Vidensk. Selsk. Skr. Række 5, Bd. 8, ii. p. 66.

1876. *Astrophyton Agassizii*, Norman, Proc. Roy. Soc. vol. xxv. p. 208.
1877. *Astrophyton Agassizii*, Lyman, Proceed. Boston Soc. Nat. Hist. vol. xix. p. 102.
1877. *Astrophyton arcticum*, Smith, MS.

Disk with prominent radial ribs, which taper slightly towards their inner extremities, and reach nearly to the centre,—their outer extremities forming a bold protuberance at the margin of the disk, above the junction of the rays. The ribs bear a number of irregularly disposed, short, conical spinelets, or spiniform tubercles. The disk is covered with a leathery skin; and upon the interradial spaces, which are smooth and well shield-shaped, a few granules are present. Mouth-shields either quite insignificant or aborted. The side mouth-plates, which are large and irregularly pyriform in outline, meet along the greater portion of their apposed sides. The jaws (*scutella oralia*) are nearly as large as the side mouth-plates, subtriangular in form, and touch along their apposed sides, except for a short distance at the aboral extremity of the same. In spirit it is difficult and often impossible to distinguish the various parts, in consequence of the thick investing skin. Mouth-papillæ and tooth-papillæ, which are spiniform and slightly tapering, are undistinguishable in form; 6–10, which may, by their position, be classed as the former, are disposed on the margin of the jaw-plate, whilst an irregular group stands in the place of tooth-papillæ. The interbrachial spaces on the actinal surface contain a few calcareous plates or scales; and at the extreme margin a closely aggregated number of these plates form a band which divides the upper and lower surfaces of the disk. Under arm-plates variable and divided; side arm-plates broad and band-like. The tentacle-scales, which are spiniform and not flattened, are normally four in each series, this number being diminished by one or two on the portion of the ray below the first forking. Rays forked dichotomously, the portions between the forks being comparatively long and unequal in length. Upper surface of the rays granulated, each joint being marked off by a suture-like depression, and the granules being gathered into a saddle-like point on the sides of each joint. A similar sutural depression or furrow traverses the dorsal median line of the ray. Towards the extremity the granules form a regular double series round the joint, the space between neighbouring series being several times the breadth of the band. These granules have claw-like hooklets articulated upon them, which are attached to a right- and left-hand knob alternately, and are present in greatest numbers towards the terminal portion of the rays. The ray up to the first forking has but very few granules, the stem next the disk being covered with a thick investing membrane.

Colour.—According to Stimpson, the radial ribs are yellow, and the interbrachial spaces brown, in the living animal. In dried examples the ribs are a yellowish brown, the rays being somewhat lighter in shade, and the interbrachial spaces a rich dark brown. In spirit preparations this difference is less marked, and frequently destroyed altogether.

Remarks.—In the preliminary Report on the Echinodermata collected during the Arctic Expedition of 1875–6 (Ann. & Mag. Nat. Hist. ser. 4, vol. xx. p. 468), an

example belonging to this species was cited under the name of *A. arcticum*, Leach, the writers, as there stated, not having had at the time an opportunity of seeing the specimen. Upon subsequent examination the *Astrophyton* in question, which had been dredged off West Greenland by Mr. A. C. Horner (who accompanied Sir Allan Young in the 'Pandora'), at a depth of 600 fathoms in Smith's Sound, lat. 78° 19′ N., long. 74° 30′ W., was found to be identical with the species which had been described by Stimpson as *A. Agassizii*, a form not uncommon in the Arctic Seas of Greenland and North America. Careful and thorough search was then made for Leach's type specimen of *Gorgonocephalus arcticus* (obtained by Sir John Ross), which was deposited in the British Museum. Prof. F. Jeffrey Bell very kindly took much trouble on our account, and rendered every assistance in his power by carefully looking up all the specimens in the national collection. Unfortunately it is impossible to say with certainty that the object of our quest was found. An old dried specimen, however, is still extant which is *supposed* to be Leach's type, and which, from its fragile nature, has never been moved since it was originally set out *by him*. This is at least the traditional (!) representative of *Gorgonocephalus arcticus*; for it is without ticket of any kind. Although this absolute evidence is wanting, there appears to be little doubt about the correctness of the supposition. This old specimen would seem to be unquestionably referable to Stimpson's species, and also to accord most closely with the example which forms the subject of the present remarks. If, therefore, the specimen above mentioned be really the *Gorgonocephalus arcticus* of Leach, that name and *Astrophyton Agassizii* of Stimpson will stand as synonymous terms.

We quote in full the original diagnosis given by Dr. Leach; as a further evidence in support of our views, and also as a testimony to the careful study and acumen of Mr. Edgar A. Smith, who was the first to refer to this hitherto overlooked and almost forgotten description:—

> "Genus Gorgonocephalus, Leach (1815). *Euryale*, Lamarck (1816).
> "Species *Arcticus*. Corpore supra radiatim costato: costis tuberculatis, radiis longissimis, tenuibus, supra granulatis; articulis (apicalibus præsertim) distinctissimis."*

From the brevity and ambiguity of this description, together with the element of uncertainty which is now inseparable from the type, and which can never be cleared away, we do not feel justified in restoring Dr. Leach's name in the face of the present universal adoption of Dr. Stimpson's; although, if all points were equal, the former would undoubtedly claim priority.

Distribution.

a. *Northward up Smith's Sound*: Lat. 78° 19′ N., long. 74° 30′ W., 600 fms.

* 'A Voyage of Discovery in H.M.SS. 'Isabella' and 'Alexander' for the purpose of exploring Baffin's Bay and enquiring into the probability of a North-west Passage.' By John Ross (1819), Vol. ii. [Append. No. iv. by W. E. Leach], p. 178.

(*Horner* in '*Pandora*'), the most northern locality on record. Lat. 73° 37′ N., long. 77° 25′ W., 800 fms. (*Sir John Ross*). Off Hare Island, Waigat Strait, lat. 70° 30′ N., 175 fms. ('*Valorous*' *Exped.*).

b. *North of American Continent*: Gulf of St. Lawrence (*Lyman, Verrill*). Grand Manan, 30 fms. (*Verrill*). Eastport, at low water of spring tides amongst rocks (mostly small specimens), and abundantly (all sizes) in 15–20 fms., shelly and stony bottom (*Verrill*). Cape Cod (*Atwood*, fide *Lyman*).

c. *North of European Continent*: Vadsö, Finmark (*Lütken*).

Description of the Illustrations of this Species on Plate V.

Fig. 1. Abactinal aspect of the animal: reduced about one third.
2. One mouth-angle of a much smaller specimen: magnified.
3. Portion of a ray, abactinal aspect: magnified.
4. Portion of a ray below the first forking, actinal aspect: magnified.
5. Portion of a ray, side view: magnified.
6. Portion of a ray near the extremity: magnified.
6*a*. One of the hooklets: magnified.

CRINOIDEA.

Three species of Comatulæ were obtained in high latitudes during the British Arctic Expedition of 1875–76, under Capt. Sir G. S. Nares. These were *Antedon Eschrichtii* (the widely distributed northern form), *A. celtica*, and a new species dredged in Discovery Bay. Respecting the general occurrence of the Crinoidea within the Arctic Circle, or even within the area treated of in the present memoir, we shall refrain from speaking, as, unfortunately, this group has hitherto been much neglected by naturalists, either from the difficulty of obtaining material in a satisfactory state of preservation, or from the complexity of the subject itself. From this cause little confidence can be placed in many of the determinations.

Mr. P. Herbert Carpenter is at present engaged in a critical investigation of the Comatulæ; and having had the opportunity of examining very extensive series of specimens (amongst others those of the 'Challenger' Expedition, of which he has already published a preliminary report*), we feel that the result of his labours, when completed, will embrace an amount of actual knowledge which, in comparison with an analysis of the confused determinations of previous writers, will prove to be so much more trustworthy and acceptable to biologists at large, that no further remark upon our reticence in that direction will be necessary.

Antedon Eschrichtii (*Müller*), *Verrill*. Plate VI, figs. 1–4.

1841. *Alecto Eschrichtii*, Müller, Archiv f. Naturgesch., Jahrg. vii. vol. i. p. 142.
1853. *Alecto Eschrichtii*, Stimpson, Mar. Invert. Grand Manan, p. 12.
1857. *Alecto Eschrichtii*, Lütken, Vid. Meddel. N. Forening i Kjöbenhavn, 1857, p. 55.
1862. *Comatula Eschrichtii*, Dujardin & Hupé, Hist. Nat. Zooph. Échinodermes, p. 199.
1866. *Antedon Eschrichtii*, Verrill, Proceed. Boston Soc. Nat. Hist. vol. x. p. 343.

Dorsocentral semiglobular, closely covered with a great number of cirri, a hundred pits being present in large specimens. Frequently, in old examples, the immediate apex is smooth and not pitted; and sometimes this portion of the plate is slightly indented, forming a little hollow or depression, surrounded on all sides by cirri.

The first radial is invisible (or with only the smallest trace to be seen at the sides in small examples), the second radial appears on the outer surface only as a very short, thin plate at the margin of the dorsocentral, and is seen to thicken at the sides as it recedes inwards; the third (or axillary) radial is a large, conspicuous plate, rhomboid or somewhat diamond-shaped in external contour, length greater than the breadth; the sloping sides, which diverge from the distal angle on the margins of the articular facet being somewhat incurved and slightly longer than the lower sides, which join to form the proximal angle, these latter sides being incurved for their distal half and then gracefully bent outwards to form the slightly rounded proximal angle. Considerable variation

* Proc. Roy. Soc. no. 194, 1879, p. 392.

is to be found in different specimens in this lower angle; and when very obtuse a much smaller relative proportion of the length of the plate lies below a horizontal line drawn through the lateral angles, than is the case when the proximal angle is smaller.

The first brachial joint is short and cuneiform; the second often as long as, or even longer than, broad; the proximal margin forming a fairly acute angle in the profile contour of the plate. This joint has also the appearance of being very considerably twisted round to the front; so that the afore-mentioned proximal angle is found opposite the middle part of the margin of the horizontal suture of the first brachial, when seen from the front. The third brachial is a comparatively short joint, of nearly equal length at either side, and bears the first syzygy. The succeeding joints of the ray have their longer side shorter than their breadth, and taper wedge-form to the other side,—their profile, when seen from the exact median line of the ray, being regularly triangular. On the lower portion of the ray, the angle formed by the longer side of the arm-joints and the proximal suture is prolonged into a prominent peak, which is also brought somewhat forwards. The neighbouring joint has a little corresponding projection or lip, upon which this articulates; and owing to this structure, a semitubercular or knobby character is given to the lower portion of the ray, which is highly characteristic of the present species. The rays are very robust, and maintain this character throughout. Towards the extremities the joints become very short, and their breadth equal to several times the length of their longer side. Syzygies occur on the 3rd, 8th, 12th, 15th, 18th brachial joint, and so on—the first two being very constant, the third sometimes varying onto the 11th or 13th joint; in the latter case the next syzygy does not occur till the 18th brachial is reached.

The pinnules are very robust, 100 being present on the one side of an arm of a moderate-sized specimen; and the joints are more or less compressed. The first five or six upon the ray have the flattened dorsal prominences which give the peculiar saw-like character mentioned by Müller and others. As a rule, the lowest pinnules in this species are of fairly uniform length, increasing slightly as they proceed along the ray; sometimes, however, the first pinnule is somewhat longer than its immediate successors; but there is no great disparity in the second and third, such as occurs in the two next species.

In a first pinnule, measuring 20 millims., were 45 joints; in another, a fraction longer, 48 joints; and the third and fifth pinnules measured, within a fraction, the same length. A pinnule taken midway along the ray was 25 millims., and had 36 joints—in this position the joints being relatively longer and more cylindrical, and their distal margin finely denticulate. In all the pinnules after the first eight or ten, the two lowest joints are very much larger than the rest, and they maintain this disparity throughout the ray; their form, also, is noteworthy, the first or articulatory joint being very compressed and somewhat halfmoon-shaped, whilst the proximal margin of the second joint is also considerably incurved, so that a large vacant space is left between the two joints, which is occupied by muscle or ligament,—these first two joints being the only ones that preserve along the ray the slightest trace of the dorsal carinæ, which have been mentioned above as characteristic of the joints of the entire

pinnule at the commencement of the series. The ovarial sacs attached to the pinnules are large and thick—a circumstance which, in conjunction with the closeness of the pinnules to one another, adds to the compact and dense character of the plume as a whole.

The dorsal cirri are long and robust; and the joints are slightly compressed. Considerable variation occurs in the length and in the number of the joints. A long example measuring 60 millims., contained 42 joints; and another, on the same specimen, about half that length, had 32. The longest joints, which commence at about the 12th from the base, are twice as long as broad, and are somewhat dicebox-shaped, the proportion of length to breadth diminishing rapidly towards the extremity. The terminal joint consists of a robust claw as long as the preceding joint; the penultimate joint bears no secondary claw, but simply has the margin thickened and produced into a sharp angle—a development which also occurs to a certain extent on several of the preceding joints.

Locality.—Franklin-Pierce Bay (*Feilden*).

Description of the Illustrations of this Species on Plate VI.

Fig. 1. *Antedon Eschrichtii*: natural size.
2. Diagrammatic sketch of the radial plates.
3. Extremity of one of the dorsal cirri: magnified.
4. A first pinnule: magnified.

ANTEDON CELTICA (*Barrett*), *Norman*. Plate VI, figs. 5 & 6.

1857. *Comatula Woodwardii*, Barrett, Ann. & Mag. Nat. Hist. ser. 2, vol. xix. p. 32, pl. vii. f. 1 (non Forbes).
1857. *Comatula celtica*, Barrett, Ann. & Mag. Nat. Hist. ser. 2, vol. xx. p. 44.
1865. *Antedon celticus*, Norman, Ann. & Mag. Nat. Hist. ser. 3, vol. xv. p. 104.
1877. *Antedon celticus*, Marenzeller, Denksch. k. Akad. Wissensch. Wien, Bd. xxxv. p. 24 (separate copy).

Dorsocentral semiglobular or hemispherical, and somewhat flattened*. Sixty to seventy cirrus-pits may be traced on the specimens under notice. A cirrus measuring 40 millims. in length has 38 joints: these are somewhat flattened; and the longest occurs at about the 9th or 10th, which is twice as long as broad—this proportion gradually decreasing as they approach the extremity, where the breadth is greater than the length. The terminal joint is a robust claw, longer than the preceding joint, which has the opposed margin angulated and sharpened, but not enough to form a secondary claw. In the smaller cirri, however, this sharpened joint is more conspicuous. In the shorter cirri, which are scarcely half the length of those above mentioned, the average number of joints is about 25, and the distal extremity of each joint is broader than the proximal which next succeeds, in a more marked degree than in the older cirri.

* Mr. P. Herbert Carpenter has figured and described this piece as elongate and conoid in young specimens (Trans. Linn. Soc. Zool. ser. 2, vol. ii. p. 61, pl. iv. fig. 8). No trace of this shape remains in our examples, which measure about 135 millims. in length.

The three radial plates are visible; the first is a very short band-like plate at the margin of the centrodorsal; the second is comparatively long, and diminishes with a somewhat rapid but graceful curve into a neck-like form at the distal extremity upon which the axillary radial is articulated; and there occurs in the median dorsal line a slight prominence or lip opposed to the proximal angle of the axillary. This latter, which is the third radial plate, is quadrately diamond-shaped in its outer contour, and somewhat broader than long, the distal angle being more obtuse and the margins of the distal facets much less incurved than in the preceding species. The first brachials are also relatively longer and more conspicuous than in *A. Eschrichtii*; and the second brachials are subtriangular or even subcrescentiform in profile (as seen from outside), and are broader than long, their apex being brought forward very considerably to the front. The third brachial, which bears the first syzygy, is nearly as long as broad. At some distance from the disk the joints of the ray are almost as long at their deepest part (*i. e.* on their longer side) as they are broad, the length of the shorter side being, perhaps, rather more than one third of the breadth on the lower third of the ray. The sutures of the joints are not nearly so much inclined as in *A. Eschrichtii*; and the joints diminish in length as they approach the extremity of the ray. Syzygies occur normally on the 3rd, 8th, 12th, 15th brachial, and so on—although the second is sometimes found on the 9th, the third on the 13th or 14th, and the fourth on the 16th or 17th brachial joint.

80–90 pinnules occur along one side of a ray. The arms, as a whole, are long, tapering, and decidedly delicate in character, although so numerously pinnulated; whilst the narrowness of the calyx, the angle of ray-attachment, and the comparative shortness of the pinnules give a very long and narrow appearance to the closed plume.

The first and second pinnules are equal in length, measuring 15 millims., and contain 36 joints each. The third pinnule is very much smaller, being scarcely 11 millims. long, and with only 23 joints. One from the middle of the ray has likewise 23 joints, and measures 15 to 16 millims. long. In another specimen the first pinnule had 37 joints, and the third 18. The joints on the proximal third of the first three pinnules have the dorsal side produced into flattened processes, similar to those developed much more prominently in the last species. The pinnules beyond the first three have very much longer joints, as will be seen by reference to the measures above given; and these are also more cylindrical in shape. In these pinnules, furthermore, the first two joints are much flatter, broader, and shorter than the rest, but do not present the conspicuous character noted in *A. Eschrichtii*. The ovarial sacs are thin, delicate, and semitransparent, presenting a very marked difference in comparison with those of the latter species.

Remarks.—It is not without considerable hesitation that we have referred the form under notice to Barrett's species; for the original diagnosis is so meagre that little can be made out of it. Dr. Marenzeller, however, has given a perfectly intelligible and more comprehensive sketch of (what is in our opinion) the same species, in the description which accompanies his determination of examples obtained by the Austro-Hungarian Arctic Expedition, with which specimens ours would seem to accord in all essential particulars.

Mr. P. Herbert Carpenter (*loc. cit.*) has entered with great care and detail into certain parts of the anatomical structure of a Comatula referred to under this name; but no other writer, excepting those mentioned above, appears to have spoken of *A. celtica* from a systematist's point of view*.

Locality, &c.—Discovery Bay, lat. 81° 41′ N., 25 fathoms, hard bottom (*Feilden*); Franklin-Pierce Bay.

Description of the Illustrations of this Species on Plate VI.

Fig. 5. *Antedon celtica*: natural size.
6. Diagrammatic sketch of the radial plates.

Antedon prolixa, *Sladen*, sp. nov. Plate VI, Figs. 7–10.

Dorsocentral very conoid, as long as, or longer than, broad, with four or five tiers of cirri arranged one above the other, about 60 to 70 all together being present; the apex having no pits, and presenting the appearance of a sort of tubercular boss. The cirri are remarkably long and delicate—one, with the extremity missing, measuring 58 millims. Another, 47 millims. long, has forty joints; and this appears to be the average length and number. One of the small cirri (which is 21 millims.) has twenty-nine joints. The joints of the cirri are very long and cylindrical, but narrower in the middle than at the extremities; the eighth from the basal joint measures 1·76 millim. long and ·43 millim. broad, or four times as long as broad; the terminal joint is modified into a delicate claw; and no actual secondary claw occurs at the extremity of the penultimate joint, only a slightly produced triangular peak.

The first radial is not visible in front, only at the extreme sides, where it may be seen rising up towards the interior. The second radial is of moderate length, nearly as long at the sides as broad, and is not much (if at all) constricted at the distal extremity. The third or axillary radial is very regularly quadriform, placed diamond-wise (the length being about equal to the breadth), and with all the sides incurved. The first brachial is comparatively long; the second longer than broad, and subtriangular in profile from the outside, the proximal angle remaining in a much more lateral position than in either of the preceding species; the third brachial, which bears the first syzygy, is as long as, or longer than, broad; and the succeeding joints of the ray are all comparatively long, and increase in relative length towards the extremity of the ray. Syzygies occur normally on the 3rd, 8th, 12th, and every third joint beyond.

On the whole it may be said that the radials stand very high in this species, and that the rays spring off from them well separated into pairs—the rays being comparatively thin and delicate in habit, and the pinnules being seemingly placed wide apart, in consequence of the length of the joints.

* Since writing the above, we have had the opportunity of examining specimens which we owe to the kindness of Sir Wyville Thomson, and which he, in common with other British naturalists, has been in the habit of regarding as the representatives of *A. celtica*. They are altogether different from the Comatula here described, and resemble to a certain degree the form that we have named *A. prolixa*, but from both of which they are, in our estimation, a perfectly distinct species.

41 pinnules are present on one side of the longest unbroken ray, which measures 86 or 87 millims.,—a little portion of the extremity being wanting. From the axillary radial to the third syzygy measures 14·5 millims. The first pinnule measures 10 millims. long, with 26 or 27 joints; the second is very short, being only 3·25 millims., and has 11 joints; the third is 5 millims., with 11 joints; the tenth 8 millims., with 12 joints; the twentieth about 14 millims., with 19 or 20 joints. In another example the first three pinnules have 22, 15, and 14 joints respectively.

The joints of the pinnules are cylindrical and very long, excepting the first six of the first pinnule, which are little longer than broad, and slightly compressed; and the three or four lowest joints in the second and third, which are also short and somewhat flattened, and diminish rapidly in breadth at their distal extremities. The second joint of the pinnules along the ray is broad and robust in comparison with the rest; and the proximal extremity is truncated on either side, so as to form apparently two sloping and converging facets for the reception of ligament: owing to this circumstance, and also to the mode of their attachment, the pinnules have the semblance of being placed transversely upon the first joints; and this presents a striking character about the middle of the ray. Ovarial sacs fine, delicate, and chiefly developed on the proximal third of the pinnule.

Remarks.—The present species more nearly resembles *A. phalangium*, Müller, of the Mediterranean, than any other Comatula with which the writer is acquainted. That it is distinct, however, from that form will readily be seen from the preceding description. It is altogether different from its Arctic congeners.

Locality &c.—All the specimens of this species were dredged by Capt. H. W. Feilden during the British Arctic Expedition of 1875–76, in Discovery Bay, lat. 81° 41′ N., depth 25 fathoms, hard bottom. *Antedon celtica* was also obtained in company with them.

Description of the Illustrations of this Species on Plate VI.

Fig. 7. *Antedon prolixa*: natural size.
8. Diagrammatic sketch of the radial plates.
9. Extremity of one of the dorsal cirri: magnified.
10. Joints with pinnules attached, from near the middle of a ray: magnified.

GENERAL CONCLUSIONS REGARDING DISTRIBUTION.

Of the Holothuroidea, *Myriotrochus Rinkii* is the most polar in its distribution; for it has been found in Discovery Bay and to the south as far as Labrador; and its habitat to the east is in the seas of Spitzbergen to Novaya Zemlya &c. *Chirodota lævis* has also a wide Arctic distribution, but is found further to the south than the last-mentioned: Godhavn, in Greenland, and Finmark and the Lofoten Islands are its limits in one direction, and Sitcha and Ochotsk in another. Then *Cucumaria frondosa* is distributed from Godhavn to Florida, from Spitzbergen to the British Isles, and to San Francisco. Of the species of *Psolus*, one is found from Godhavn to Maine and across to Iceland and the British Isles; whilst the other extends far to the east, but appears to be restricted to the polar waters. The most restricted species was *Orcula Barthii*, which was found at Holsteinborg and has been found off Labrador.

The only species of Echinoidea, *Strongylocentrotus dröbachiensis*, has a vast distribution, as far north as Discovery Bay, and south to Florida, from Iceland to Spitzbergen, and Novaya Zemlya to the British Isles. It has been found in Behring's Straits, Kamtschatka, and on the American coast to Vancouver. Fed upon by Asteroids, and caring little for a bottom temperature of 29° Fahr., this species is very typical of the collection under consideration. It is essentially a polar species, migrating now and then to the south; and it forms part of a true polar fauna.

The *Asteracanthia* have one species as far north as Discovery Bay; and it extends southward to Newfoundland and across to Novaya Zemlya; the other lives from 70° N. lat. to Labrador, but it has a polar distribution, as it extends to the Ochotsk sea. *Stichaster albulus* is found at Franklin-Pierce Bay to Godhavn and Grand Manan; the eastern habitat is from Iceland to Spitzbergen. *Cribrella oculata* is distributed from 70° N. lat. to Massachusetts, Iceland, Spitzbergen, Scandinavia, and White Sea, and is found in the English Channel. Moreover this vast area is enlarged by the discovery of the form in the Sea of Ochotsk.

The new species of *Pedicellaster* is esentially a dweller in the Palæocrystalline sea of Nares.

As might be supposed, *Crossaster papposus* has a vast distribution. Nearly circumpolar, it extends along the European and eastern American coasts, along the

north of the European and Asiatic continents, and is found in Behring's Straits. Finisterre and Massachusetts are its most southern habitats.

Solaster endeca has been found in Smith's Sound, Newfoundland, Iceland, and in the English Channel; and Brandt obtained it at Sitcha. The solitary species of *Lophaster* is very Arctic, being found at Discovery Bay; and it extends south in the Gulf of Maine and at Bergen.

Pteraster militaris has almost a corresponding, but slightly intermediate range; and the *Ctenodiscus* extends far over the north of the European continent, comes only as far south as Mainc in America, and reaches to lat. N. 70° 30′ off Greenland.

It is evident that the grouping of these Asteroids is as if they were part of a great Polar fauna, with no very great southern distribution.

Of the Ophiuroidea, the new species *Ophiopleura arctica* belongs to a genus characteristically Arctic. The *Ophioglyphæ*, with the exception of *O. Stuwitzii*, are found very far to the north; and their fellow Ophiuroidea at Discovery Bay and Franklin-Pierce Bay are *Ophiocten sericeum*, *Amphiura Holbœlli*, and *Ophiacantha spinulosa*. The range of these resembles that of the Asteroids to a certain extent; and they have curious structural affinities with even the forms from the Korean Sea. The forms with a smaller northern area are the *Ophioglyphæ* just alluded to and *Ophiopholis bellis*.

The *Astrophyton* ranges from 78° N. lat. up Smith's Sound to Cape Cod, and has been found at Vadsö, in Finmark.

Antedon Eschrichtii and *A. celtica* are widely distributed northern forms; and the new species *Antedon prolixa* is from Discovery Bay.

When these details are carefully considered, it becomes evident that each one of the great groups of Echinodermata tells the same story regarding distribution. The fauna, as a whole, is not an extension northwards of species from more temperate climates, but is essentially circumpolar. The modifications in the character of the species are probably due to variation produced by the changes of condition which necessarily occur in different parts of any great area.

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[Synonyma are printed in italics.]

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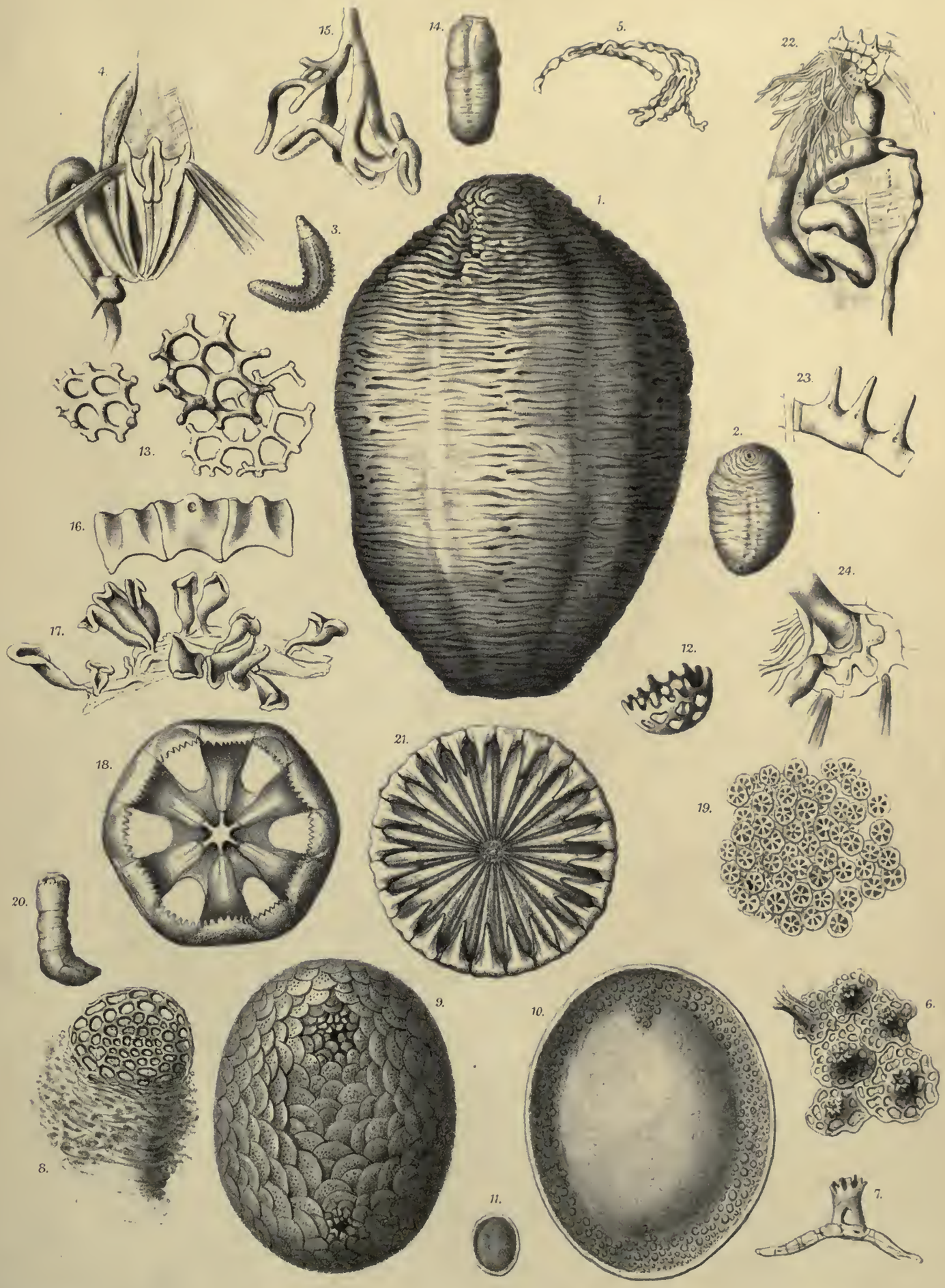
PLATE I.

HOLOTHUROIDEA.

Figure 1. Cucumaria frondosa (Gunn.), Forbes. Natural size.
2. A young specimen of the same, natural size.
3. Cucumaria calcigera (Stimp.), Selenka. Natural size.
4. Sketch of the mouth-ring and adjacent parts of a young individual, magnified.
5. Generative tubes at an early stage of growth, magnified.
6. Spicules of the superficial layer *in situ*, magnified.
7. Small spicule in profile, magnified.
8. Disk at the extremity of the sucker-foot, magnified.
9. Psolus Fabricii (D. & K.), Lütken. Dorsal aspect, natural size.
10. The same specimen. Ventral aspect, natural size.
11. A young specimen. Ventral aspect, natural size.
12. One of the small cup-like spicules of the ventral integument, magnified.
13. Spicules of the ventral integument, magnified.
14. Chirodota lævis (Fabr.), Grube. Natural size.
15. Generative tubes, magnified.
16. Portion of the mouth-ring, magnified.
17. The pyriform infundibular organs or "Wimpertrichter," magnified.
18. One of the wheel-like spicules, magnified.
19. One of the sacculi, to show the aggregation of the spicules, magnified.
20. Myriotrochus Rinkii, Steenstrup. Natural size.
21. One of the spicules, magnified.
22. Sketch of the internal organs, showing the relative proportions of the alimentary canal, the Polian vesicle, and the generative tubes.
23. Portion of the mouth-ring, magnified. (In this drawing the upward prolongations ought to taper more rapidly, and the foramina ought to be further up from the base.)
24. Underside of the mouth-ring, with parts attached, seen from below, showing the dilatations of the oral water-vessel.



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Arctic Holothuroidea.

PLATE II.

ECHINOIDEA and ASTEROIDEA.

Figure 1. Strongylocentrotus dröbachiensis (O. F. M.), A. Ag. Abactinal aspect, natural size.
2. The same specimen, seen in profile, natural size.
3. Portion of test near the ambitus, showing the ambulacral and interambulacral areas, magnified.
4. Asteracanthion polare, M. & T. Abactinal aspect, reduced one half.
5. Actinal aspect of the same specimen, reduced one half.
6. Portion near the middle of a ray, actinal aspect, magnified.
7. Portion near the middle of a ray, abactinal aspect, magnified.
8. A similar portion from the more compactly spinulated variety of this species, magnified.
9. Asteracanthion grœnlandicum (Steenstrup), Lütken. Abactinal aspect, natural size.
10. Actinal aspect of the same specimen, natural size.
11. Portion near the middle of a ray, actinal aspect, magnified.
12. Portion near the middle of a ray, abactinal aspect, magnified.
13. Stichaster albulus (Stimps.), Verrill. Abactinal aspect, natural size.
14. A larger and almost equal-rayed variety from Proven.
15. Actinal aspect of the same specimen, natural size.
16. Portion near the middle of a ray, actinal aspect, magnified.
17. Portion near the middle of a ray, abactinal aspect, magnified.
18. Cribrella oculata (Linck), Forbes. Abactinal aspect, natural size.
19. Actinal aspect of the same specimen, natural size.
20. Portion near the middle of a ray, actinal aspect, magnified.
21. Portion near the middle of a ray, abactinal aspect, magnified.
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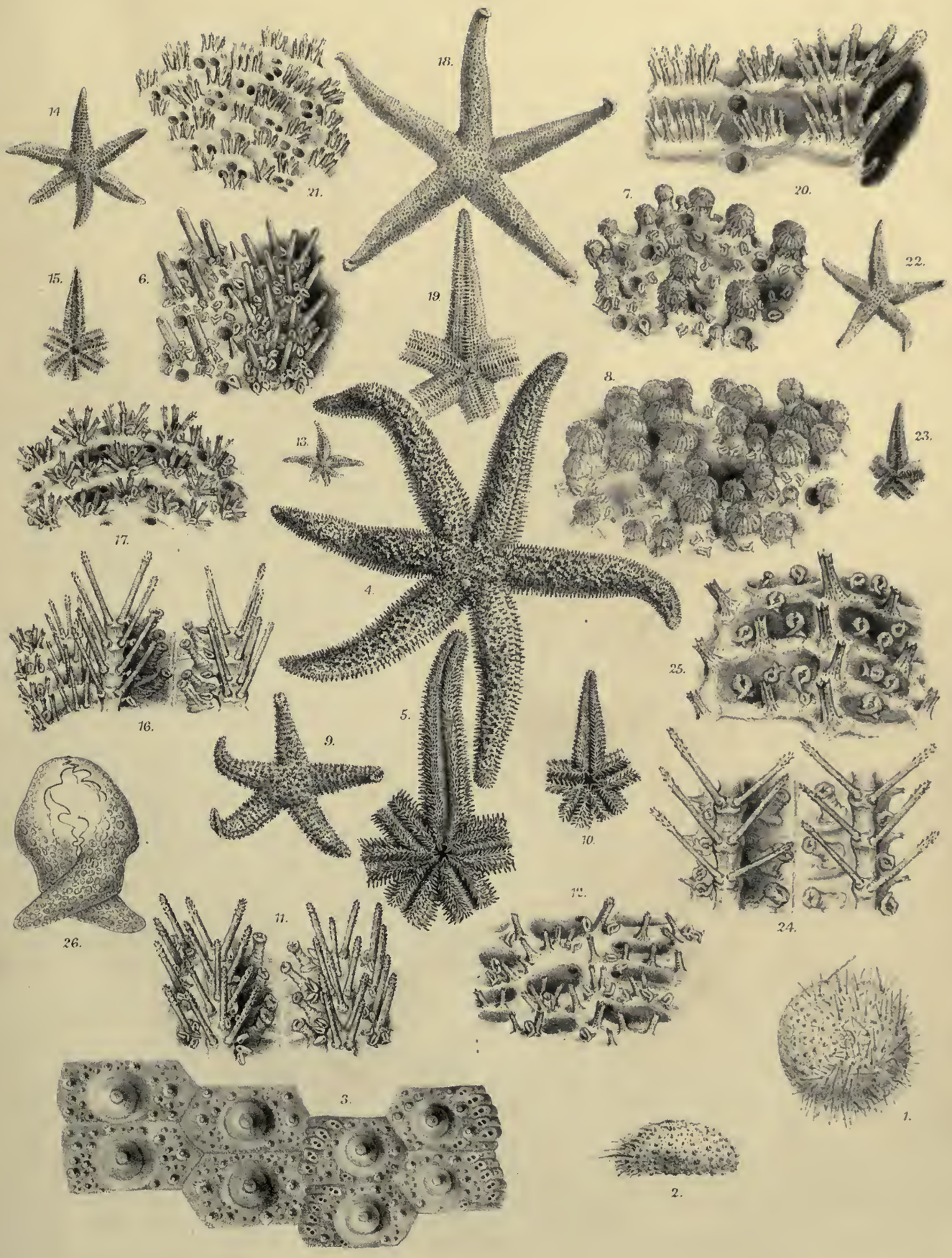
26. One of the pedicellariæ, magnified.



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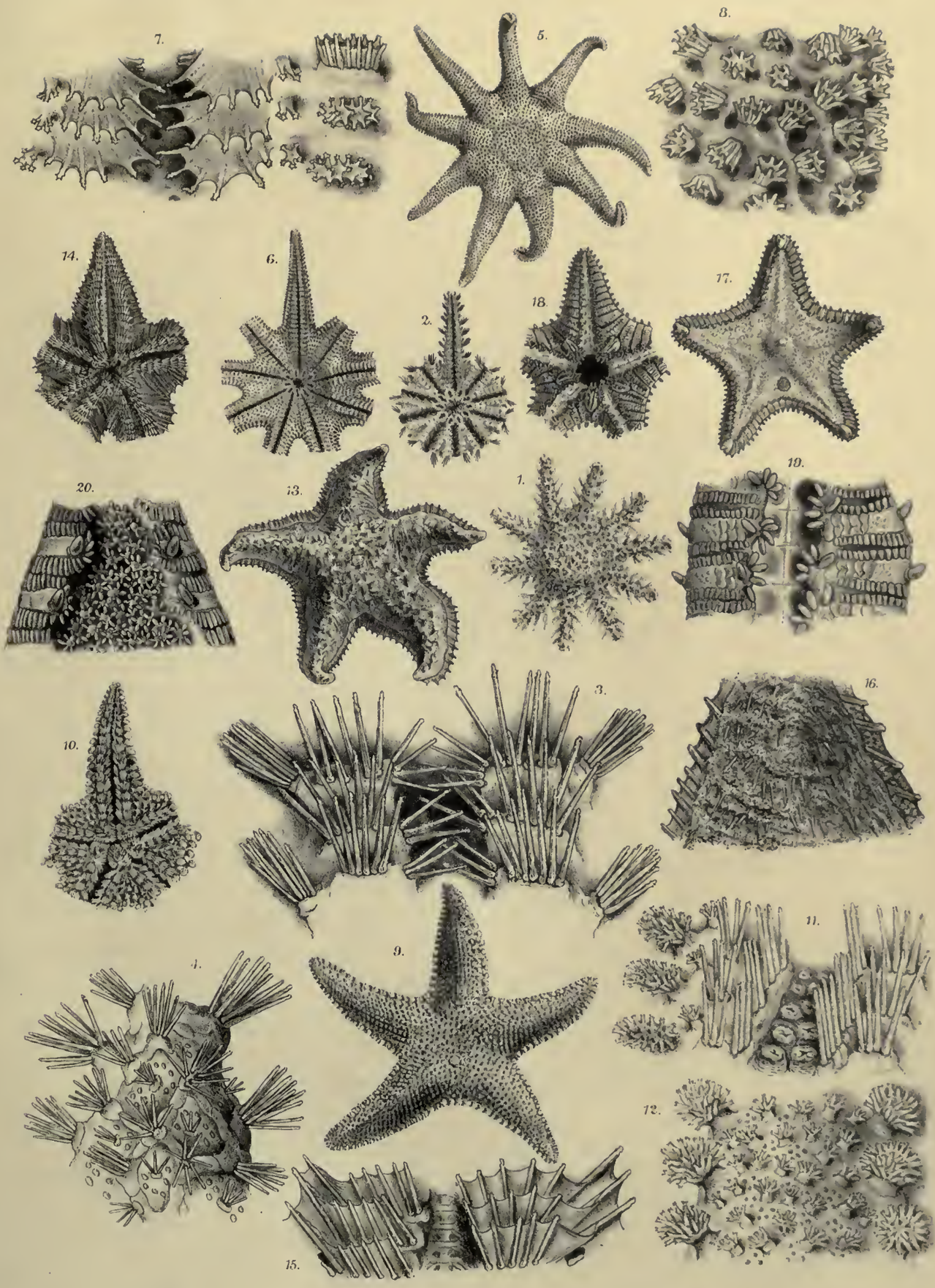
Arctic Asteroidea and Echinoidea.

PLATE III.

ASTEROIDEA.

Figure 1. Crossaster papposus (Linck), M. & T. Abactinal aspect. Young specimen.
2. Actinal aspect of the same specimen, natural size.
3. Portion near the middle of a ray, actinal aspect, magnified.
4. Portion near the middle of a ray, abactinal aspect, magnified.
5. Solaster endeca (Gmel.), Forbes. Abactinal aspect, natural size.
6. Actinal aspect of the same specimen, natural size.
7. Portion near the middle of a ray, actinal aspect, magnified.
8. Portion near the middle of a ray, abactinal aspect, magnified.
9. Lophaster furcifer (D. & K.), Verrill. Abactinal aspect, natural size.
10. Actinal aspect of the same specimen, natural size.
11. Portion near the middle of a ray, actinal aspect, magnified.
12. Portion near the middle of a ray, abactinal aspect, magnified.
13. Pteraster militaris (O. F. M.), M. & T. Abactinal aspect, natural size.
14. Actinal aspect of the same specimen, natural size.
15. Portion near the middle of a ray, actinal aspect, magnified.
16. Portion near the middle of a ray, abactinal aspect, magnified.
17. Ctenodiscus corniculatus (Linck), Perrier. Abactinal aspect, natural size.
18. Actinal aspect of the same specimen, natural size.
19. Portion near the middle of a ray, actinal aspect, magnified.
20. Portion near the middle of a ray, abactinal aspect, magnified.



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Arctic Asteroidea.

PLATE IV.

OPHIUROIDEA.

Figure 1. Ophiopleura arctica, Duncan. The upper part of the disk and arms, natural size.
2. The under surface of the disk, magnified.
2 *a*. The teeth on the jaw-plate, oblique view, magnified.
2 *b*. The teeth, from above, magnified.
2 *c*. The teeth, approaching, magnified.
3. Ophioglypha Sarsii (Lütken). From above, natural size.
4. The underpart of the disk, magnified.
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7. The upper surface of the disk, magnified.
8. Ophiocten sericeum (Forbes). The upper surface, slightly magnified.
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10. Part of the underpart of the disk, magnified.
11. Ophiacantha spinulosa. The upper surface, natural size.
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13. The spines on the disk, magnified.
14. Ophiocten sericeum (Forbes). Part of the disk-scaling, magnified.
15. Amphiura Holbœlli. Part of the underpart of the disk, magnified.
16. Radial shields, magnified.
17. Side view of the arm, magnified.

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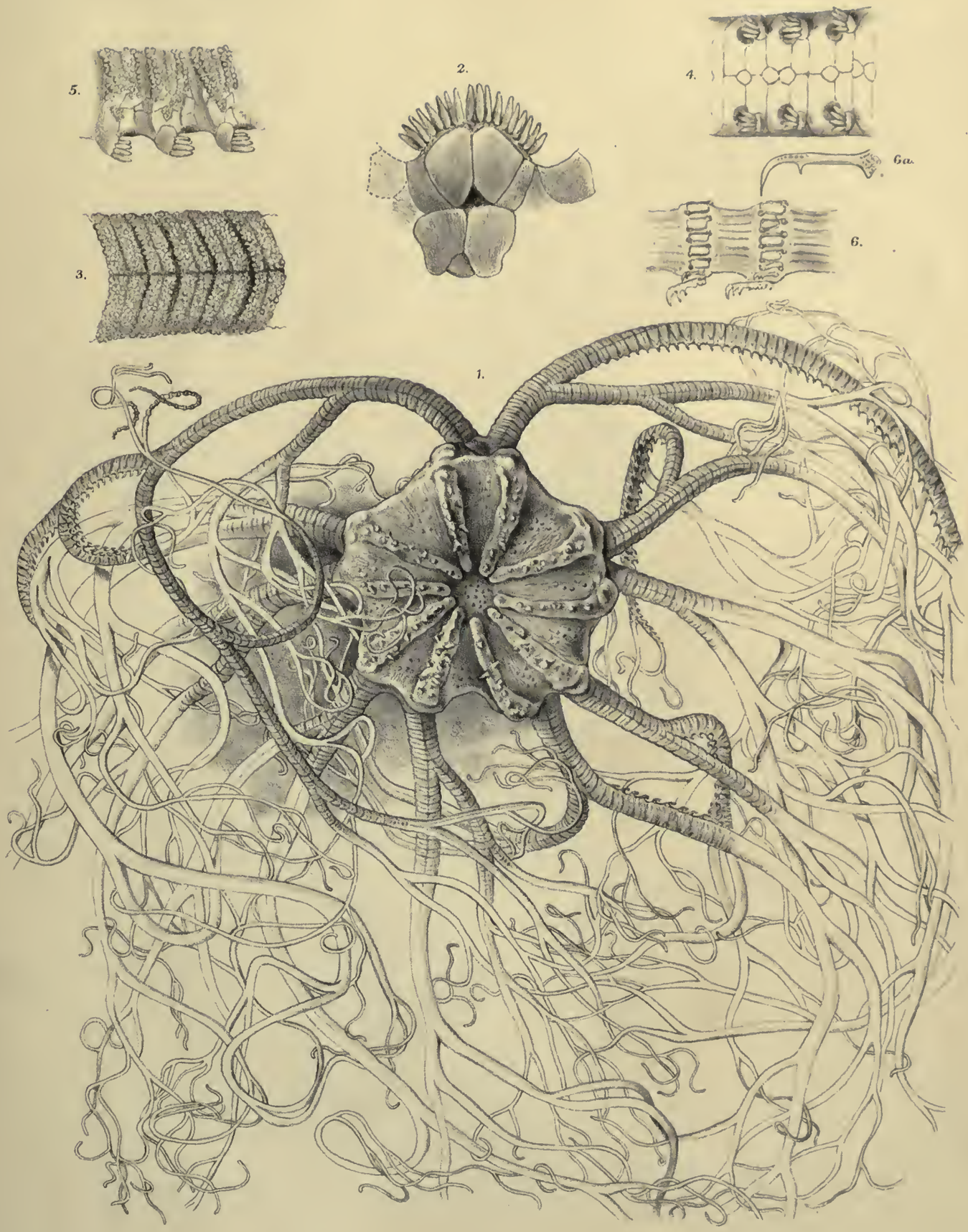
Arctic Ophiuroidea.

PLATE V.

ASTROPHYTIDÆ.

Figure 1. Astrophyton Agassizii, Stimpson. Abactinal aspect, reduced about one third.
2. One mouth-angle of a much smaller specimen, magnified.
3. Portion of a ray, abactinal aspect, magnified.
4. Portion of a ray below the first forking, actinal aspect, magnified.
5. Portion of a ray, side view, magnified.
6. Portion of a ray near the extremity, magnified.
6*a*. One of the hooklets, magnified.



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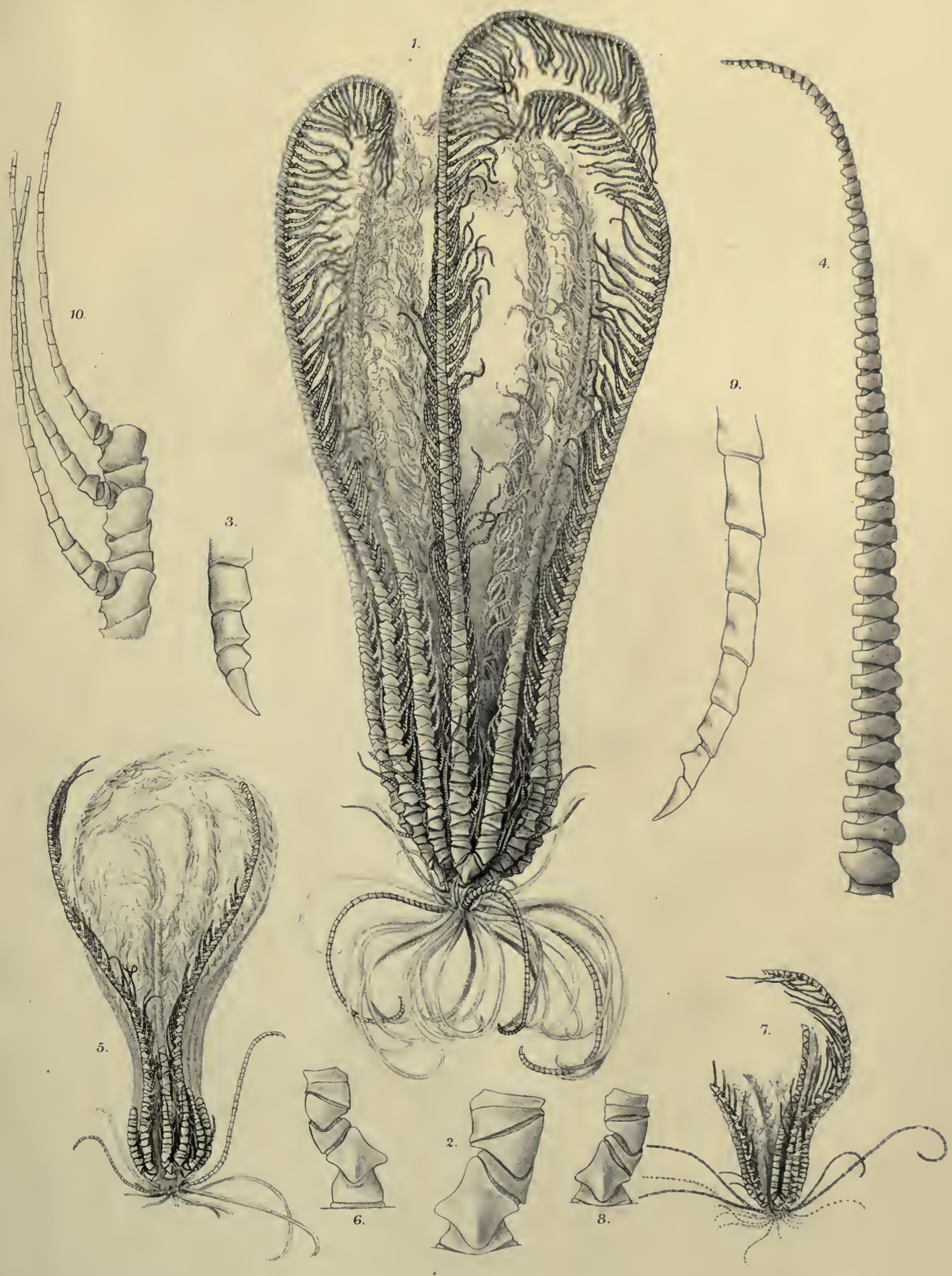
Arctic Astrophyton.

PLATE VI.

CRINOIDEA.

Figure 1. Antedon Eschrichtii (Müller), Verrill. Natural size.
2. Diagrammatic sketch of the radial plates.
3. Extremity of one of the dorsal cirri, magnified.
4. A first pinnule, magnified.
5. Antedon celtica (Barrett), Norman. Natural size.
6. Diagrammatic sketch of the radial plates.
7. Antedon prolixa, Sladen. Natural size.
8. Diagrammatic sketch of the radial plates.
9. Extremity of one of the dorsal cirri, magnified.
10. Joints with pinnules attached, from near the middle of a ray, magnified.



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Arctic Comatulæ.

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